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ANILINE DYE IN AQUATIC WEED CONTROL

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Since the inception of fisheries management in fresh water, men have striven to develop methods of controlling aquatic vegetation. Although a certain amount of water weed is desirable for fishing waters, overabundance of such plants invariably leads to trouble of some sort.

Aquatic plants may cause waters to become difficult to fish, and reduced fishing loads often lead to overpopulations, particularly of warm water species. Overpopulations are also indirectly caused by weeds through providing too good cover for young fish which should normally provide a significant part of the diet of large fish, particularly of bass.

Anyone who has worked with aquatic plants has noted that clear, shallow lakes are particularly susceptible to weed growths. Rooted plants are unable to thrive in deep water because light does not reach them in sufficient quantity to promote photosynthesis. Neither do they grow in turbid waters and for the same reason. The writer has found that even slight muddying of the water in a stream is enough to cause photosynthesis to drop off in plants present and to cause a high *pH* to fall rapidly.

In the summer of 1944 when the writer was striving to arrive at a solution to the weed problem in many Arizona waters, the idea was conceived of artificially darkening weedy waters so as to cut down on the amount of light reaching the plants, thus inhibiting their growth. The obvious agent for the purpose was a dye of some sort.

At first glance the cost seemed to be too great to overcome. In laboratory quantities, standard dyes or stains such as nigrosine sold for about $15.00 a pound. However on contacting several producers of dyestuffs, it was found that the same nigrosine could be purchased for 36 cents a pound in 100 pound lots. Other black dyes were in the same price range, although somewhat higher. Samples of Ox intense black, Putnam's fadeless black, F and S neutral black and National nigrosine were diluted to one part per million of water and placed in a well-spaced row on the top of a rock wall in the strong Arizona sunshine in January.

Putnam's fadeless black was noticeably lighter in shading at this dilution than the other three, which were more or less uniform. In three days the Ox intense black and Putnam's fadeless black had faded almost completely out, while the F and S neutral black and National nigrosine were apparently un-

changed in intensity. After three months the neutral black was slightly faded, while the nigrosine had virtually retained its original appearance.

In the meantime, after a few weeks' trial had indicated that the nigrosine was holding up best, a larger sample of this was ordered and two ponds in the Hunt Bass Hatchery, some ten miles from Phoenix, were treated. One of these is a half acre and the other some three acres in surface area. Both have steep sloping sides over most of the shore, with occasional large shoal areas. Depth of the water at the dams is approximately 16 feet. All ponds in this hatchery are of the same character and have about the same depth at the dams. Conditions are excellent for weeds, which thrive even through the winter months.

The half-acre pond selected for trial is designated Number Eight in the hatchery plan and the three-acre one is Number Six. On January 17, one pound of nigrosine was placed in Number Eight, lowering its visibility from 14 feet to four feet by Secchi disc reading. Ten pounds of nigrosine in Number Six lowered its visibility from 13 feet to six feet.

For the next three months this concentration was maintained in the two ponds, although it was necessary to add dye from time to time to compensate for dilution occasioned by water running through the ponds. In addition to inhibition of weed growth, some unlooked-for results were obtained. Near the end of April a great amount of zooplankton and phytoplankton developed in the two treated ponds, causing them to become markedly more turbid than were the untreated ones. This was caused possibly by decay of organic material on the bottom in the absence of light. The condition prevailed for only a month, however, after which the ponds stayed relatively clear.

Darkening of the waters also reduced the temperatures in the lower levels of the ponds. Evidently the infrared rays were kept from penetrating very far below the surface. Following is a tabulation of temperature readings from the surface and from a 15 foot level in each pond.

Pond	*Surface Temperature*	*Temperature 15 ft. depth*
2	77°	71°
3	76°	71°
*6	77°	65°
7	77°	73°
*8	77°	68°

* Treated.

By May it was decided that the treatment was demonstrating itself successful enough to warrant proceeding on a larger scale. Enough dye was ordered to treat Ashurst Lake, an alkaline problem water of static qualities, and Granite Basin Lake, another static water that had caused trouble for trout through alkalinity. Acting on indications gained from the experimental work done at the Hunt Bass Hatchery, these lakes were treated at the rate of ten pounds per acre. Treatment was calculated in pounds per acre rather than in parts per million because the nature of the dye's action makes this a more constant figure. In other words, deep lakes need less per unit volume than shallow ones because the cumulative effect of depth compensates for the reduced concentration.

Shortly after application, however, it was found that concentrations effective at the bass hatchery were not suffi-

cient for the clearer water of the treated lakes. Visibility in Ashurst Lake was lowered to only eight feet from its original 14 and Granite Basin Lake was lowered to seven from an original 16. It was not possible nor practical to further treat Ashurst Lake because of the size, but 50 per cent more dye was applied to Granite Basin Lake, which has a surface area of but 11 acres.

In the interim, the *pH* of these two waters had risen from neutral to 9.5 in Ashurst and to 9.6 in Granite Basin, a normal springtime phenomenom in these waters caused by increased photosynthesis of the aquatic plants removing carbon dioxide and thus resulting in bicarbonates breaking down into alkaline carbonates. Ashurst Lake never rose any higher during the summer, although conditions were better for weeds and alkalinity than in the previous year when the *pH* rose to above 10.2, and the aquatic vegetation was much inhibited in the deeper water. After the second application the *pH* in Granite Basin Lake dropped to 7.6 and declined below that figure the rest of the summer. Long tendrils of *Potamogeton crispus*, the dominant weed species in this lake, in water over six feet in depth, turned white and dropped to the bottom. The second application lowered the visibility to four feet. By September the concentration of dye in each lake was apparently about 60 per cent of that at time of application.

In the treatment of Ashurst Lake a great deal about lake currents was learned that could be of value to anyone engaged in the treatment of lakes with herbicides, fertilizers, fish poisons or any soluble substances. As before stated, Ashurst Lake is a body of water of some 200 acres. Maximum depth is 18 feet and the average depth is about 10 feet. Due to this shallow condition, it is in a constant state of turnover.

As the dye was not known to have been used previously, methods of application had to be worked out. First tried was the trolling of bags of dye in back of boats, but the substance immediately formed a large lump in the bag and dissolved quite slowly. Then bags were placed in the water at strategic points. This resulted in rapid spread of the dye, but the rate of solution was still slow. Finally the simple method of shovelling the dye into the water on the rocky bottom at points was tried and found to be most effective. In less than 24 hours the dye was not only dissolved, but completely dispersed throughout the lake. Secchi disc readings found the concentrations uniform over all of the lake in less than 24 hours after the dye had been shoveled into the water.

The rapid diffusion of the dye indicated the tremendous amount of current in a lake of this type. For illustration: on one afternoon 350 pounds of dye were dumped in the water at one point. A streak of dark water, clearly discernable at the surface, immediately started moving across the bottom of the lake, and in less than an hour had reached entirely across to the far beach, some 1000 yards away. Other streaks fanned out in other directions at equal speeds. All of the dye seemed to travel along the bottom first. By the next morning at nine o'clock, the lake was uniformly colored. This indicated the rate at which solutions can be expected to cover a lake, an important item in the use of poisons, such as rotenone.

The dye project was more or less dropped in 1946 because it was deemed too expensive for the larger bodies of water which were the ones in which the department was particularly concerned. Some interesting and unexpected results of the 1945 treatment developed in 1946, however. Early spring found the weeds in Granite Basin Lake much inhibited and the dye still about 50 per cent of original strength. The *pH* of the water never reached lethal height all summer.

Ashurst Lake provided more evidence of the dye's effects. Although the water level was three feet lower than in 1945, no weeds reached the surface and all were much inhibited over the entire lake. In this lake as well as in Granite Basin, the weeds appeared to lack strength to go to the surface, instead feebly growing over each other horizontally near the bottom. In this lake also, the dye seemed to be about 50 per cent of original strength a year after application.

This delayed effect of the dye in the weeds is somewhat difficult to explain. It would seem that results should be greatest at first when the dye is strongest. However it is possible that the concentration was always too weak to cause any lethal exclusion of light from the plants, and it was cumulative starvation that produced the weakened condition the following spring. Or the original application might have been made too late in the spring of 1945, after the weeds were too far advanced. Perhaps the time to treat with dye would be in the fall, so that the weeds are denied light from the start in the spring.

Final results in the hatchery ponds near Phoenix were not conclusive, although it seemed that after the water was fertilized and temperatures exceeded 85°F. the weeds came on in spite of the dye. It was difficult to evaluate the true results, as fresh water was run through the ponds continuously for a month before draining, diluting out the dye completely. As soon as the water cleared, the weeds came on with a rush.

It would seem that this method of weed control is of sufficient promise to warrant further experimentation. While it seems too expensive for larger waters, it might be of value in small important ponds. It might be much more effective and for a longer period of time elsewhere than in the southwest, where over 300 cloudless days per year are experienced, and the piercing rays of the sun tend to encourage weed growth and to destroy dye. The tenacity of the nigrosine dye is somewhat astonishing even in Arizona however. Eighteen months after Ashurst Lake was treated, it was still at least 40 per cent of original darkness. As the *Myriophyllum*, dominant in this lake, was kept from maturing, it is possible that 1947 will see a further reduction of weeds in this lake, regardless of any remaining dye.

SUMMARY

1. Analine dye has been tried in Arizona as an inhibiting agent for aquatic plants through exclusion of light.

2. Out of several dyestuffs tested, nigrosine was found to be cheapest and most permanent.

3. By experiment it was found that darkening of ponds caused lowering of

Aerial view of Ashurst Lake in the foreground 18 months after treatment with dye. Note lighter color of untreated lakes in background.

the bottom temperature and a temporary increase in plankton.

4. Dye was applied to two lakes at the rate of 10 pounds per acre, which was found to be insufficient. More was later added to one of the lakes.

5. The best method of application was found to be dumping of the dye in shallow water at points. Dispersal was complete in a 200-acre lake in less than 24 hours.

6. Greatest effect of the dye was noted the following year when normally semi-emergent weeds failed to reach the surface.

7. The method needs more experimentation in waters of more cloudy and cooler regions.

THE TENCH IN AMERICA

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While accumulating materials for a bibliography of the Texas fishes, the writer became interested in the attempt once made to establish the European tench, *Tinca tinca*, in American waters. Inquiry of the United States Fish and Wildlife Service in regard to early plantings by the United States Fish Commission, in the days of Dr. Baird, elicited a letter from Dr. T. K. Chamberlain, who wrote:

"I glanced over the list of fishes sent you as having been planted by the federal service at some time or other in Texas, and was struck by one species listed. . . . I promptly wrote our regional director: 'I was considerably astonished to see the name tench listed. I became especially interested in the fish when I found it on sale in the fish market at Jefferson City, Missouri (in 1945) as "Idaho Bass." It was first introduced from Italy into this country in 1922, by a Mr. Graviati (see "The Tench in California," by Leo Shapovalov, in the January, 1944, number of California, Fish and Game). He planted it in a farm pond in San Mateo County, California, and other farm pond owners spread it extensively. Apparently it has become common in certain Idaho waters'."

Shapovalov's paper (1944) was consulted, as were those of Marr (1940) and Dill and Shapovalov (1939), but beyond these I was unable to find any further published material on the modern distribution of the fish, or anything to indicate its survival from the earlier plantings in question. However, in a second letter, Dr. Chamberlain stated that the species is apparently well established in both California and Colorado, but that he had only secondary evidence of its occurrence in other western states. Evidently he believed, prior to seeing my letter to the Fish and Wildlife Service, that all the western fish were decended from the San Mateo planting, which had spread. As far as California goes, this probably is correct, for there were no tench in the waters of the state until after the Graviati planting. The Fish Commission had never planted any there, although they did attempt to introduce them into Oregon

Washington, Nevada and Idaho (Smith 1896), and if present conditions are any indication, evidently met with considerable success in the last-named state.

The history of these earlier plantings is most interesting, hinging, as it does, upon the early efforts of the Commission to acclimatize European fishes in this country.

On August 20, 1875, a Dr. A. O. Finsch wrote from Bremen, Germany, to Dr. Spencer F. Baird, our first Commissioner of Fisheries, as follows: "Hessel obtained at Lubbinchen goldtench (*Cyprinus tinca* var. *auratus*)." In a later letter he says: "the tench is a fish which I recommend you highly, being hardy and easy to transport."

Hessel was Rudolph Hessel, for many years in charge of the United States Fish Commission ponds at Washington, and the tench were later shipped to this country along with some carp and golden orfes, or ides. Dr. Baird writes, in 1879, "Fully appreciating the tenacity of life of the tench, and the readiness of its acclimation in foreign waters as shown by the prodigous success of the experiments with it in Australia, I requested Mr. Hessel on his return from the last trip to Europe[1] to bring with him as large a number as he could, and these have also been placed in Druid Hill Park. The especial value of this fish is in the fact that as the waters of a given pond dry up or flows off, it buries itself in the mud, and if this is kept sufficiently moist, it will remain in perfectly good condition, while, perhaps, the ground above it will become hard and parched, requiring only the return of water to its bed to permit its emergence. Indeed, it is said in some places where the ground is hard, and the fish is needed, it is dug out, like potatoes from a hill. The fish will be distributed together with the carp, as there is nothing incompatible in their occupying the same waters.

"A few special varieties of what is known as the golden tench were obtained, and will be propagated; but they have no special value beyond their abnormal color."

Tench were first artificially propagated in this country by Hessel in 1881. In the Report of the Commissioner for 1883 it is mentioned that a small number were cultivated in that year (1883) but that there was little demand for them as stocking fish. In 1884 there were 6,000 young produced. In 1885, only 1,206 tench were raised at Central Station, Washington.

In 1886 at Central Station less than 1,000 tench were raised, due to the ravages of eels which got into the rearing ponds. Two breeders and 450 yearlings were shipped to Wytheville Station, Wythe County, Virginia, and while the breeders were retained, the 450 yearlings were planted in the South fork of Reid Creek. In 1888 provision was made to rear the species at Neosho, Missouri, for introduction into the southwestern states, and tench were produced also at Washington, in this and the following year, although most of the 1889 crop was lost due to floods from the Potomac inundating the ponds and releasing many of the fish. However, enough survived that during the fiscal year of 1888–1889, the Commission distributed a total of 1,530 yearling tench.

For the fiscal year of 1889–90 the

[1] The trip was made prior to May 1878, when Rudolph Hessel landed at New York.

commissioner reported 24 tench in the Washington Ponds, and for 1890–91, 1678. Tench were also produced during this period at Neosho, Missouri. I can find no record of any distribution in 1889–90, but the following year tench were planted.

In the fiscal year of 1891–92 the tench spawned in June in the Washington ponds and 9,600 were produced. Neosho, Missouri, had good luck also, raising 26,432 to sufficient size for shipment. In all, 35,592 tench were shipped during the year.

The following year, ending June 30, 1893, Washington ponds furnished 10,022 tench, but at Neosho the good results heretofore attained in propogating tench were not realized. The total production was only 10,000. Depredations of crawfish were thought to have caused this poor production.

A year later (1894) a new attempt was made to raise tench, at Wytheville, Virginia, due to the increased demand for fish stocking purposes. During the winter of 1894–1895, 50 two year olds were placed in the ponds at that place. These fish were observed spawning on May 31, June 7 and June 20, and at the close of the month many fry were seen in the water. At Neosho, 275 tench were on hand at the beginning of the fiscal year, but the breeders apparently spawned a second time, late in August, and a second crop of 4,600 was harvested late in the fall. The following spring, spawning occurred on April 12 and again on June 2, but the superintendent of the hatchery, W. F. Page, stated "It is improbable that any results will be secured, as a number of bass escaped from Pond 10 into the tench pond."

Although no production was obtained from Wytheville in this year, a very large number of tench was again distributed from the Washington ponds and from Neosho.

During the fiscal year of 1895–96, tench production was still large. Wytheville produced 3,000. Neosho's crop was a failure. Mr. Page's prediction had come true. The introduction of black bass into the ponds during floods, along with the escape of fry at the same time, had been sufficient to decimate the stock.

Thus between the years 1886 and 1896 the Commission distributed tench to the states shown in the following summation.

Alabama (1888–89)[2]	
Various applicants	634
Alabama State Fair Association, at Pelika	25
Arizona (1894–95)	
Various applicants	145
Arkansas (1893–94)	
Various applicants	1,480
Colorado (1890–91)	
Various applicants	145
Delaware (1892–93)	
Delaware Fish Commission	300
Appoquinick River, at Middleton	200
Various applicants	24
District of Columbia	
Zoological Park	500
Potomac River	1,024
Various applicants	140
Florida (1894–95)	
Various applicants	555
Georgia (1888–89)	
Augusta National Exposition, at Augusta	25
Appalachee River	2,000
Oconee River	2,000
Etowah River, at Jasper	1,000
Long Swamp Creek, at Jasper	1,000
Tate's Pond, at Jasper	1,000

[2] The figure beside the state name is the year the state first occurs in the Commissioner's reports.

Flint River, at LaGrange	4,000
Savannah River, at Augusta	60
Various applicants	4,725
Idaho (1895–96)	
Diamond Lake, at New Port	500
A lake and pond in Kootenai Co., and a pond in Latah Co.	258
Illinois (1891–92)	
Hickory Creek, at Martinsville[3]	500
Kaskaskia Creek, at Vandalia	500
Des Plaines River, at Des Plaines	500
Various applicants	210
Indiana (1888–89)	
Whitewater River, at Richmond	500
Various applicants	265
Iowa (1891–92)	
Iowa Fish commission	50
Des Moines River, at Ottumwa	3,700
Line Creek, near Mason City	50
Bishop Lake, at Sheldon	40
Cedar River, at Osage	25
Iowa River, at Chester	500
Various applicants	100
Kansas (1888–89)[4]	
Brookville	200
Kansas Fish Commission	300
Brickner River, at Jetmore	100
Various applicants	3,186
Kentucky (1894–95)	
Various applicants	440
Louisiana (1894–95)	
Various applicants	80
Maryland (1888–89)	
Monocacy River, near Frederick Junction	1,400
Patuxent River, at Laurel	1,000
Big Pool, at Hagerstown	1,000
Deer Creek, at Bel Air	1,000
Youghiogheny River, at Oakland	150
Various applicants	597
Massachusetts (1895–96)	
Various applicants	115
Mexican Republic (1888–89)	
City of Mexico	200
Michigan (1890–91)	
Various applicants	30
Missouri (1890–91)	
Missouri Fish Commission	10,025
Hickory Creek, at Neosho	3,160
Shoal Creek, at Bayden	5,500
North Fork at Spring River, at Lamar	4,000
Current River, at Chilton	2,300
Grand River, at Chillicothe	3,700
Meramec River, at Moselle	7,930
Various applicants	1,940
Nebraska (1894–95)	
Nebraska State Fish Commission	1,000
Various applicants	306
Nevada (1885)	
Virginia City	20
New Mexico (1894–95)	
Manco Bunco Creek, Raton	200
Various applicants	1,140
New York (1891–92)	
New York Fish Commission	2,100
Various applicants	4,000
North Carolina (1891–92)	
Mayo and Dan Rivers, Reisdale, N. C.	3,000
Catawba River, at Marion	638
Various applicants	2,243
Ohio (1891–92)	
Big Darby Creek, at Plainfield	500
Spring Creek, at Urbana	500
Tinker Creek, at Bedford	200
Ohio Fish Commission	800
Various applicants	972
Oklahoma (1889–90)	
Shawnee	1,000
Blue River, near Armstrong	600
Kingsfisher Creek, at El Reno	100
Various applicants	3,167
Oregon (1895–96)	
Alden Springs, at Laurel	50
Pennsylvania (1888–89)	
Brandywine River, at Reading	3,000
Brandywine River, at Chadd's Ford	992
Tulpehocken River, at Reading	1,500
Ontelaunee River, at Reading	1,500
Jacob's Creek, at Mount Pleasant	150
Mendehall Lake, at Mendenhall	30
Conodoquinette Creek, at Carlisle	150
Tributory of the Susquehanna at Selinsgrove	200
Various applicants	850
South Carolina (1894–95)	
Congaree River, at Columbia	1,000
Broad River, at Blacksburg	500
Various applicants	1,499
Tennessee (1894–95)	
Cove, Hickory and Dair's Creek	300

[3] I often fished this creek as a boy, but do not remember anything in it but sun-perch and catfish.

[4] An earlier date than this is given in Volume 5, Bull. U. S. Fish Comm., p. 67, which notes that 200 tench were delivered to Brookville, Kansas, on November 24, 1884.

Campbell County	300
Tennessee River, at Loudon	300
Tennessee River, at Knoxville	200
Lamberton and Jones Creeks, at Jonesboro	300
Stone River, at Murfreesboro	200
Harpeth River, at Newsom	200
North Fork, Forked Deer River, at Trenton	300
Jellico Creek, at Gumfork	300
Various applicants	823
Texas (1891–92)	
T & P Railroad pond, at Arlington	500
T & P Railroad pond, at Loraine	1,500
Colorado River at Austin	2,100
San Marcos River, at San Marcos	2,700
Exall's Lake, near Dallas	1,000
Canyon Lake, near Cisco	1,000
Chesley Tank, near Cisco	300
Delmark Tank, near Cisco	300
Longview Pond, at Longview	1,000
Palestine Fishing Club Lake, near Palestine	2,000
Trinity River, Forth Worth	1,800
Various applicants	3,768
Utah (1895–96)	
Various applicants	90
Virginia (1891–92)	
Reid Creek at Wytheville	450
Appomatox River, at Petersburgh	2,000
Tate's Run, at Wytheville	400
Crab Creek, at Wytheville	150
Various applicants	670
Washington (1895–96)	
Fourth of July Lake	200
Fetz lake and a pond in Spokane Co.	200
West Virginia (1895–96)	
Various applicants	123
Wisconsin (1895–96)	
Various applicants	90
Total	138,599

The death knell was sounded in 1896, however, for any further attempts on the part of the Commission to propagate these fish for distribution, and after that the ponds devoted to that purpose were repaired and utilized for the rearing of bass.

What happened to these fish that were planted? Where did the tench go? The Commission had planted between the years 1886 and 1896 over 138,000 of them. Had they disappeared, or had they taken root in their new home and prospered?

In an effort to find out, the author wrote the conservation department of each of the states mentioned above, inquiring as to the presence of tench in their waters. Six replies were in the affirmative, and another, Massachusetts, while disclaiming the presence of the fish, noted its occurrence in another state in which no planting was recorded.

Mr. William C. Herrington writes:

"I have been unable to find any data indicating the presence of tench in Massachusetts waters at present. However, a recent survey showed tench in one body of water in Connecticut, and the New York Department of Conservation had a few tench in one of their hatcheries lately."

Actually, he goes on to say, this was at the Cornell University Hatchery at Cortland, N. Y. Tench evidently occur in that state, for Nichols and Gregory (1918) say:

"Two other European species have been introduced and occur locally" (i.e., in New York).

Bean (1903) also mentions the species in his "Fishes of New York" and lists a specimen from the Potomac River at Washington, D. C., this last of course, being really a Maryland record. Four specimens from this locality are in the National Museum collections, U.S.N.M. 31003, 37850, 30336 and 27234.

In Maryland proper the fish are considered a nuisance. Mr. Frank L. Bentz of the Game and Inland Fish Commission says:

"Concerning the planting of *Tinca tinca* in the various streams and lakes of Maryland by the Federal Government, these fish propagated so well that they really were a nuisance in our waters. We wish they had never

been planted. They made such progress in Deep Creek Lake that it was impossible to catch any other fish but this species. We then planted this lake with large mouthed bass of adult size and today we seem to have a nice balance of the more desirable fish."

In Ohio the species evidently never became very well established. Mr. E. L. Wickliff, Chief, Fish Management Section, writes:

"In checking through Dr. R. C. Osburn's "The Fishes of Ohio," we note the following statement on page 42: '*Tinca tinca*. In the spring of 1898 a freshet carried away the banks of an artificial lake on the grounds of the Ohio State University, at Columbus, and many of the tench with which the lake was stocked escaped into the Olentangy River. In September of the same year specimens were taken at the mouth of the small stream flowing from the lake into the river. Whether the tench will hold its own in the streams of Ohio yet remains to be seen'.

"From 1920 to 1946 we have conducted fish surveys in the 88 counties of Ohio and in most of the 1,500 townships, but up to the present time I have not obtained a record for the state of Ohio."

Tench did become acclimatized in Colorado. In another letter Dr. Chamberlain says:

"Apparently the fish is established in Colorado definitely enough. That state and California are the only two so far I feel certain about, although there is secondary evidence that it is found in other western states. I got a letter this month from Charles C. Sperry of our Denver office. He wrote regarding the tench as follows: 'A few hours ago I received a report about your friend *Tinca tinca* that I am sure you will find of interest. An eye-witness told me that he saw tench caught at Tucker's Lake on March 23. Several fish were involved and they were about twelve or fourteen inches in length. Larger tench are reported to have been taken from the same lake in 1944. Tucker's Lake is near Highway 185, a few miles north of Golden, Colorado.' Mr. Gilbert Hunter of the Colorado game department told me of tench being sent in for identification from several points in Colorado. Also, Mr. Sperry mentioned specifically of having seen tench taken from one Colorado lake. The name slips me, however."

Washington evidently supports a fairly large widespread population of tench and it seems possible that they came from two sources. The Diamond Lake referred to in the table of plantings as having been in Idaho, is in Washington, according to Mr. James C. Simpson of the Idaho Department of Fish and Game. This would be the earliest planting for the state. The second is accounted for in a statement made by Dr. L. C. Schultz, and quoted by Dymond (1936). Dr. Schultz says:

"The European tench were brought to Seattle for the World's Fair, and afterwards were dumped into Geyser Basin (a large goldfish pond on the campus) and probably at that time or perhaps later were taken to Lake Union. They remain in the geyser basin today in great abundance and are collected occasionally for laboratory dissection. No attention is paid to them at all. They propagate naturally. Specimens have been reported from Lake Union that were nearly two feet long."

Dr. R. C. Meigs states that they are widely distributed and that apparently they have survived wherever they have been planted. Schultz (1929) records it from Washington, as does Chapman (1942) and Schultz and DeLacy (1935) give its range as "Columbia River, certain streams and lakes of the Puget Sound drainage. . . . Specimens were obtained in Lake Washington and Union and at Kalama, Rock Island Dam and Chelan."

Tench occur in Oregon also (Schultz, 1929; Schultz and DeLacy, 1935) and a specimen in the University of Michigan

collection was taken in the Umatilla River, according to information furnished me by Dr. Reeve M. Bailey.

The species has repeatedly been mentioned as occurring on Vancouver Island (Schultz, 1929; Schultz and DeLacy, 1935; Chapman, 1942; Lampman, 1946), but Dr. G. Clifford Carl tells me that this is not the case. However, tench do occur in British Columbia, Dymond (1936) took specimens in Christina Lake, and MacCowan and Carl got a number from Osoyoos Lake, in the Okanagan drainage (Carl and Clemens, 1947).

Apparently the only place where the species was become established in commercial quantities is the State of Idaho. Dr. Chamberlain's letter, saying that he had seen "Idaho Bass" in the markets of Jefferson City, Missouri, has already been mentioned. Mr. James G. Silver, of the United States Fish and Wildlife Service confirms this, saying:

"Most of the tench that reach the commercial markets today come from waters in Idaho."

Evidently they are not considered as an unmixed blessing, for in Mr. Simpson's letter (op. cit.) he says:

"The tench planted in Coeur d'Alene Lake in Kootenai County unfortunately survived, and are a great problem to the State of Idaho In the near future control measures must be taken if this body of water is to support game fish."

This gives us, then, California, Colorado, Washington, and Idaho in which the species is fairly well-established. Maryland reports it; it is found in Oregon in some quantities, and in the Canadian province of British Columbia; Dr. Bailey (op. cit.) has a specimen from New Mexico, and there are two in the U. S. National Museum from Missouri, and it has been reported from New York and Connecticut. In all the rest of the states, even those where it was comparatively heavily planted, it does not, as far as I know, occur. Why?

The answer probably lies within the last paragraph of Mr. Bentz' letter when he says "They made such progress in Deep Creek Lake that it was impossible to catch any other fish but this species. We then planted the lake with large mouth bass of adult size and today we seem to have a nice balance of the more desirable fish."

Most of the states in which the planting was done lie within the black bass belt of the United States, and it seems reasonable to believe that a fish such as the tench would hardly be able to gain a foothold and thrive in the face of such opposition. The three western states mentioned have a trout population, not a bass.

In my correspondence with Dr. Chamberlain this was discussed. He writes:

"The very fact that repeated efforts were made to establish the fish in Texas, seemingly unsuccessful in every instance, suggests that the tench could not live in association with the common Texas predatory, freshwater pond fishes. As you know, it is a pond fish, and does not appear to thrive in streams. In one Colorado lake I know the tench is found associated with the crappie, but as a predatory fish the crappie cannot take care of its own excess young, so this may mean little. I question whether the tench would survive where the black bass or even the goggle-eye or green sunfish had control."

Smith (1896) states that plants of the goggle-eye, *Chaenobryttus coronarius*, the crappies, *Pomoxis annularis* and *Pomoxis sparoides*, the green sunfish, *Lepomis cyannellus*, and the black

basses have all been made in the waters of the Pacific coast. Apparently these have become well-established (Hatton, 1940; Brown, 1939; Dill, 1944, 1946; Neale, 1931; Hazzard, 1946). It would be interesting to know if the tench occupies the same waters.

LITERATURE CITED

BEAN, T. N. 1903. Catalogue of the fishes of New York. Bull. N. Y. State Mus., **60**(9): 120–127.

BROWN, MERRILL W. 1939. A brief history and identification of the three species of black bass now occurring in California. Cal. Fish and Game, **25**(4): 310–312.

CHAPMAN, WILBERT MCLEOD. 1942. Alien fishes in the waters of the Pacific Northwest. Cal. Fish and Game, **28**(1): 9–15.

CLEMENS, W. A., and G. C. CARL. 1947. The fresh water fishes of British Columbia. In Press.

DILL, WILLIAM A. 1944. The fishery of the lower Colorado River. Cal. Fish and Game, **30**(30): 109–211.

DILL, WILLIAM A. and LEO SHAPOVALOV. 1939. California fresh water fishes and their possible use for aquarium purposes. Cal. Fish and Game, **25**(4): 313–324.

DYMOND, J. R. 1936. Some fresh-water fishes of British Columbia. Rept. B. C. Comm. Fish. 1935, 60–73.

HATTON, S. ROSS. 1940. Progress report on the Central Valley fisheries investigations, 1939. Cal. Fish and Game, **26**(4): 334–373.

HAZZARD, A. S. 1946. Warm water fish management. Cal. Fish and Game, **32**(1) 19–26.

LAMPMAN, BEN HUR. 1947. The coming of the pond fishes. Binford's and Mort, Portland, Ore., 173 pp., 6 ill.

MARR, J. C. 1940. Distributional note on the European tench *Tinca tinca*. Cal. Fish and Game, **26**(4): 396.

MILLER, ROBERT R., and J. R. ALCORN. 1945. The introduced fishes of Nevada, with a history of their introduction. Trans. Amer. Fish Soc., **73**: 173–193.

NEALE, GEORGE. 1931. Early history of the introduction and distribution of spiny-rayed fishes in California waters. Cal. Fish and Game, **17**(3): 238–239.

NICHOLS, JOHN T. and WILLIAM K. GREGORY 1918. Fishes of the vicinity of New York City. Amer. Mus. Nat. Hist., Handbook Series, **7**: 42–103.

SCHULTZ, LEONARD P. 1929. Check-list of the fresh-water fishes of Oregon and Washington. Pub. Fish., Univ. Wash. **2**(4): 43–50.

SCHULTZ, LEONARD P., and A. C. DELACY. 1935. Fishes of the American Northwest. Mid. Pac. Mag., **10**(4): 365–380.

SHAPOVALOV, LEO. 1944. The tench in California. Cal. Fish and Game, **30**(1): 54–57.

SMITH, HUGH M. 1896. A review of the history and results of attempts to acclimatize fish and other water animals in the Pacific states. Bull. U. S. Fish Comm., **15**: 379–472.

U. S. Bureau of Fisheries. Report of the Commissioner, **11–22**.

THE VALIDITY OF THE ROADSIDE CENSUS AS APPLIED TO PHEASANTS[1]

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Introduction

The need for a rapid method of censusing populations of Ring-necked Pheasants has resulted in the acceptance by many workers of the roadside census technique devised by Bennett and Hendrickson (1938) in Iowa. Doubtless its current widespread use stems from several positive values associated with it. Extensive areas may be censused in a brief period of time; a minimum of observers is required, and these need not necessarily be trained wildlife technicians since conservation officers, sportsmen, and others may observe and count pheasants; the cost per area censused is much less than with other census methods; and, the noticeable activity in early morning together with the size of pheasants might seem to contribute to the practicability of the technique.

Workers utilizing the roadside census have employed the data in two ways. Some (Bennett and Hendrickson, 1938; Randall and Bennett, 1939; and Hicks, *et al*, 1941) compared the number of birds seen per mile during early morning drives through areas where the population had been determined in birds per acre by other means, thereby establishing a ratio which was used as an index of the total population. Thus, it was thought that once these ratios were established the actual number of pheasants in an area of known size could be ascertained by use of the roadside census technique alone. Others, Bach (1944) and McClure (1945) used the values of birds per mile to serve as indices which permitted a comparison of the relative abundance at different times and at different places. In the latter method it is unnecessary to locate all of the birds as long as the same percentage of the total population is recorded each time. Consequently this technique is most commonly used, and its time-saving value is obvious.

Inconsistencies in the use of roadside censuses.—Despite the theoretical validity of the roadside census technique, when carried out under similar conditions in successive trials in one area, the literature is replete with inconsistencies—some trivial, others gross. Bennett and Hendrickson (1938:723) state, "The method herein explained [roadside census] can be used by conservation officers during regular patrol hours and at no extra cost to the com-

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mission. From a comparative standpoint it will become more valuable as the years go by." These investigators compared the roadside census data from an area with the known population of the same area in units of birds per acre. The latter figures were obtained by mass beating of the area by a group of men. By comparing the birds observed per mile with the known density in birds per acre for areas of different population densities, three ratios were derived. Each was considered satisfactory for that particular concentration of birds. However, these ratios did not vary together and the trend in one of the components was found to bear no constant relation to the trend of the other component. Thus no interpolation for total population figures was permitted for areas other than those in which the ratios were derived because there was no indication as to what the intermediate and lesser counts meant in terms of birds per acre. It seems apparent, then, that these ratios might be valid for one period of time in one area for one group of observers, but there is no assurance that the same ratios would be valid in another region under a different set of conditions.

In 1939 Randall and Bennett published an account of censuses in Pennsylvania wherein the methods mentioned previously for Iowa were employed. Three ratios were again computed and these, too, lacked constant relative values for different concentrations of birds. Moreover, when the ratios were plotted no near relationship was apparent between the data from Pennsylvania and Iowa; this indicates again that such ratios are valid for only one area, providing, of course, that they are sound at all. A statistical study, which appears later in this paper, of the data set forth by Randall and Bennett indicates that their ratios are much too variable to be reliable indices. However, on page 435, they state, "The cost of such a census is very low, and the method appears to be much more accurate than any other method yet devised for large areas."

Hicks, *et al* (1941) mention that the roadside census technique as employed by them in Ohio has been tested and modified each year. Yet, the manner in which the yearly results of these censuses are tabulated implies that the census figures for one year are comparable to those taken in the same area during former years. It seems reasonable to assume that if the technique employed were modified from year to year the results of the censuses would not be comparable. Thus the ultimate purpose of the censuses is defeated. The figures presented in their tables were obtained, apparently, from a single roadside count through an area and were not checked by subsequent censuses made over the same route during the same season of the same year. Nevertheless, other workers in addition to ourselves have shown great daily variability in the results of roadside censuses. Hicks and his associates also used the census figures obtained from roadside counts to compute the average number of pheasants per square mile. This ratio, based on the averages determined by numerous field surveys, was that 100 pheasants observed in 100 miles while cruising in a car indicated an average population of about 140 birds per square mile. This single index value was used by them to compute the total popula-

tion from any figures derived by means of the roadside census, since the ratio may be graphically illustrated by a straight line. This means that for a certain area the increase or decrease of pheasant populations between years is equivalent to the percentage difference in birds per mile observed in those years. Thus, workers in Ohio are at variance with those in Pennyslvania and Iowa who find that their index values cannot be plotted on a straight line and that it is impossible to estimate the total population in an area where the road count varies from the established trio of indices. An instance of improbability resulting from the use of roadside counts is shown on page 6 (Hicks, *et al*, 1941) in the figures for Sandusky County during the 1940 and 1941 censuses. The population in this area nearly tripled in one year—an improbable increment even under the most favorable conditions.

In North Dakota, Bach (1944:6) states, "So important and accurate has this annual upland game census [roadside census] become that this Department now relies on it to a great extent, . . . " His tabular information on page 8 shows that, as would be expected, more hens than cocks were seen during the census period in 1941. However, in 1942, 1943, and 1944 more cocks than hens were seen, indicating that either the populations were not adequately sampled or that the hens were secretive as in nesting or caring for broods and thus were not observed. Since the census period covered a time when reproductive activities precluded the appearance of both sexes in their true ratio, the results are questionable.

If the figure (1386) presented as the total of birds seen in 1941 (Bach, 1944:8) is correct, every bird in late July of 1941 had to live through late July of 1942 and had to produce two more birds to permit the observation of 3,899 birds in 1942. If half of the young seen were hens the total number of hens in 1941 was 725, and the total number of cocks was 660. Let us assume at least 50 per cent mortality in adults between 1941 and the breeding season of 1942. Thus, in the spring of 1942 there would be present about 367 hens and 330 cocks. Using these figures the breeding stock in 1942 would number 697 of which 367 would be hens.

Studies in Montana (Hiatt and Fisher, in press) indicate that at the maximal population levels in the fall 83 per cent of the total population consists of young birds. Buss (1946:102) finds a survival rate of approximately 15 per cent from year to year. Bach's figures for late July show that the young comprise 84 per cent of the total population. Since his data probably approximate those for the maximal population in the census area, we may assume that the adults of 1942 are survivors of the total number observed in 1941. If this be true it necessitates or indicates a survival rate of about 80 per cent over an annual period. The old-young ratio of Bach actually shows a survival rate of 40 per cent which is somewhat high.

In 1941, according to Bach's observations, a total of 146 hens produced 1,159 young or a successful brood size of 7.9. In 1942 more than three times this number of hens (482 observed) produced 2,809 observed young, necessitating a successful brood of 5.8 for every hen. The total population for 1942 (3,899)

less our calculated breeding number of 697, leaves 3,202 birds to be produced by 367 hens, or a successful brood size of 8.7. Further, it is unlikely that more than 300 of the hens actually were successful; hence, the brood size must have been greater than 10, which is abnormally high, especially when the average brood size observed by Bach in 1942 was 6.5. Thus there is a discrepancy between the total figures for 1941 and 1942, and also a disagreement in the observed proportions of the sexes in the populations for these years. These two irregularities indicate that the birds censused in the two successive years did not represent the same proportion of the two populations. However, if the censuses are directly comparable and practicable for evaluating trends in a pheasant population the proportion of the total population seen in each of the two years should be the same, and the ratio of the sexes should also be comparable.

Recently, McClure (1945:38) after attempting to utilize the roadside census for pheasants in Nebraska, states, "The results, however, are more confusing than enlightening. The variation in number of birds seen from week to week was nearly as great as that between years. . . . " When he compared census results from detonation, crowing, and roadside methods no agreement was found. McClure recognized the difficulty of using the roadside census technique as indicated by his remarks above, yet he states (p. 41), "Roadside counts are best used in the autumn as an indication of the post-breeding population." He further asserts (p. 45), that it is the best method previous to the hunting season if used "repeatedly." On page 39 his average birds per mile is given as 0.79 while in this same area the following year the average birds per mile was 3.07. Assuming that the figures may be relied upon, and that they are comparable, the population must have quadrupled—a biological impossibility for pheasants under normal conditions.

In summarizing these inconsistencies it is apparent that those proponents of the roadside technique who used it to ascertain index ratios for determining total populations are at great variance with those who employ the technique to determine the relative abundance of birds. Even among the former group of workers there is a disagreement in regard to the relation of the roadside index to the total population. Although all workers recognize that seasonal and climatic changes affect the census results, and consequently generally eliminate all counts except those made under similar conditions, they fail to recognize and consider the extensive variation common to all results thus far published. Conservation measures have been promulgated on the basis of data assumed to be reliable but which often vary several hundred per cent.

Factors affecting the results of roadside censuses.—Roadside censuses are affected by factors which may best be divided into (1) those factors which may alter the results of successive daily or weekly counts, and (2) those seasonal factors which are likely to affect the counts. Among the former are: (1) the time of day in which the census is made, (2) the weather during and immediately preceding the census, and (3) the traffic along the road. Factors which influence censuses over a longer period

of time are: (1) plant growth; (2) features of the breeding season such as mating, nesting, care of young birds, and the appearance of immature birds in the fall; (3) availability of food along the road shoulders in months of grain hauling, or the berries and fruits available in riverbottom brushlands during the winter; (4) hunting season; and (5) flocking behavior during the winter months.

Wild life technicians are generally cognizant of these influencing factors but there is no complete accord among them as to which season, what time of day, and what weather conditions produce the most reliable results in censusing.

Objectives of this study.—Because of the confused and inconsistent reports on the technique of the roadside census and because of its theoretical usefulness, it was decided to test the validity of the method in a series of comprehensive roadside censuses in two excellent pheasant ranges in Montana. Our objectives were: (1) To establish an index for each area to permit comparison of relative abundance between years and at different times during a year; (2) to determine the effect of the factors presumed to cause the great variability reported by all workers; and (3) to test the validity of the method by using it repeatedly over the same route throughout one year.

DESCRIPTION OF THE STUDY AREA

Census routes about fifty miles apart were established in the irrigated, riverbottom land of the Yellowstone and Big Horn River Valleys in the counties of the same names. The route in Yellowstone County was just east of Billings and the route in Big Horn County was just north of Hardin. Both areas are relatively level and interspersed by irrigation canals and roads. Land use in these valleys is approximately the same, and the percentage of land planted to various crops is about as follows: alfalfa, 30; fallowed land, 13; sugar beets, 12; beans, 9; oats, 8; barley, 7; wheat, 7; soil-building crops, 2.5; field corn, 2; peas, 2; timothy hay, 2; all others, 5.5.

Weeds had gained a good growth by June 1 and all small grains were headed out by the end of June. Harvesting of dry land grain started in July and grain lost in transit appeared along the road shoulders. Harvesting and threshing were virtually completed by the end of August and fall plowing was underway. Field corn was shocked by October. Mild weather followed until late January when snow covered the ground and remained until early March.

Each valley has a main through highway but traffic over these highways was light. Dirt roads follow section lines and it is not difficult to travel through the entire countryside which supports diversified farming in a fairly homogeneous distribution. These country roads are seldom traveled, particularly at the early hours used for censusing pheasants.

METHODS

Preliminary trips through the farm land were made to find the route affording the best cross-section of farming practices, a substantial population of pheasants, and the least traffic. The census strip selected near Billings was 29.5 miles in length and the one near Hardin was 24.5 miles in length. Both

led through as nearly comparable areas as were possible to locate.

In making the count the same two observers were employed for the entire year. The automobile cruised at approximately 15 to 20 miles per hour with stops made only to count and sex large flocks or broods. No stops were made to search out pheasants which may have been secluded. The observers always started at the same end of the route. All censuses were taken in the early morning since it has been demonstrated by Bennett and Hendrickson (1938), Randall and Bennett (1939), and Hicks, *et al.* (1941) that, compared to morning counts, evening counts made over the same route are highly variable and that the birds thus observed per mile bear no relation to the total population. Reasons for this are adequately summarized by these workers. The hour selected for starting was based upon sunrise and each count was started within a few minutes of sunrise and continued until the strip had been completed.

In order to follow the analysis in all of its details our data are presented in three ways. First, the raw data are offered as the basis for the analyses. Second, those factors presumed to influence the census figures are segregated and their effect is evaluated. Third, a reevaluation of the data is made in light of all of the factors found to exert some variable effect, and the final result is analyzed statistically to determine its reliability as an index to populations of pheasants.

CENSUS DATA

Results of all the censuses taken over the Billings route are shown in Figure 1. The great variability between successive censuses, many of which were made on successive days under apparently almost identical climatic conditions, is obvious. Expected trends in the population do not always appear. The upswing in March is probably correlated with the onset of breeding behavior although the population is actually declining rather than increasing. Moreover, the appearance of leaves on the vegetation would tend to obscure an increasing number of birds. A gradual decrease in the observed population is expected from spring through the early part of the breeding season because of nesting activities and general secretiveness of hens and broods, and because of the increased growth of weeds and cultivated plants. Contrary to expectations, however, more adult birds were counted in early June than at any time earlier in the year. The upswing in late summer and fall is expected because of the appearance of young, but it does not reach sufficient proportions above those counts in the spring to account for the vast increase in population. Low counts in mid-September are completely out of line. The comparatively small number seen during November and December results from hunting season pressure, but by late January the birds are again distributed normally over the countryside.

Similar variability on successive censuses was found in the Hardin area (Figure 2). The highest counts were recorded in February and March when actually the birds are most numerous in the fall. Census taken in November and December are again influenced greatly by the hunting season.

Comparisons of census results ob-

tained from the two study areas show a number of inconsistencies. Spring censuses in both areas reflected populations which were too great in comparison with fall populations. In addition, the censuses showed the spring population in one area to be completely out of line with that in the other region.

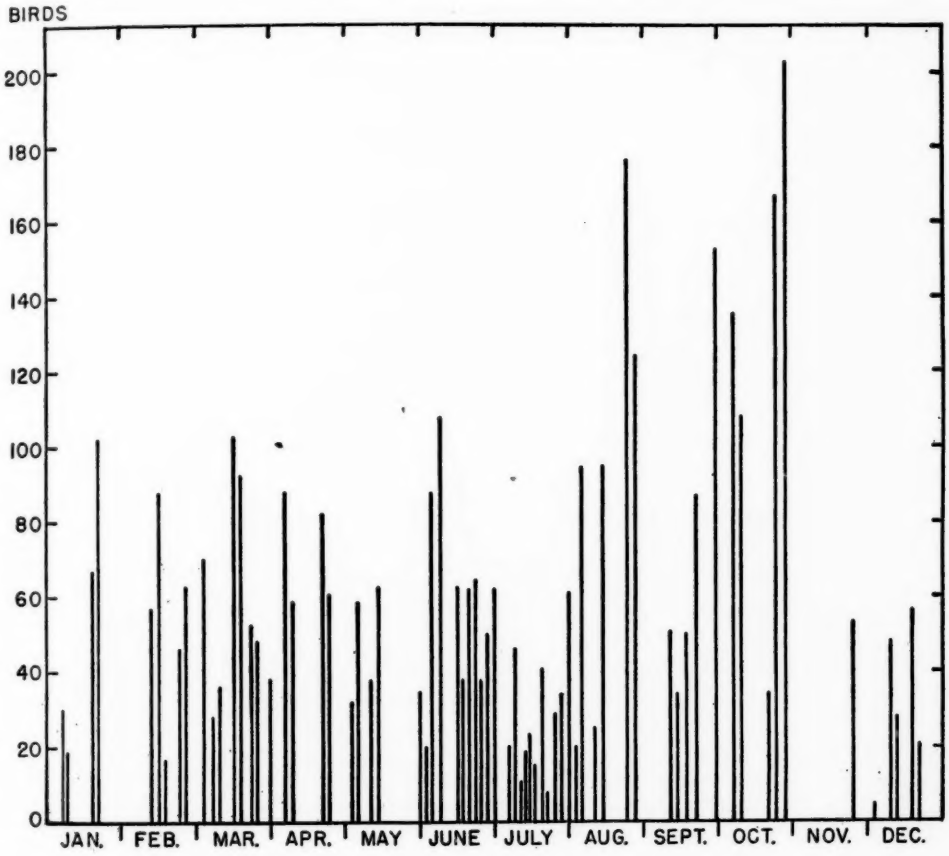

FIG. 1.—Results of all of the morning roadside censuses taken over the same 29.5-mile route in the Billings area for a period of one year.

Census results in both study areas for the months of March and October were analyzed statistically (Table 1). These months were selected because (1) the greatest number of censuses and highest monthly totals of birds were involved, (2) little courtship display and no nests or young were present, and (3) as a rule climatic conditions were moderate. Data from this table show that the range from one census to another, the standard deviation of the means of the several censuses, and the coefficient of variation (V) are very great. Thus, it was impossible to obtain

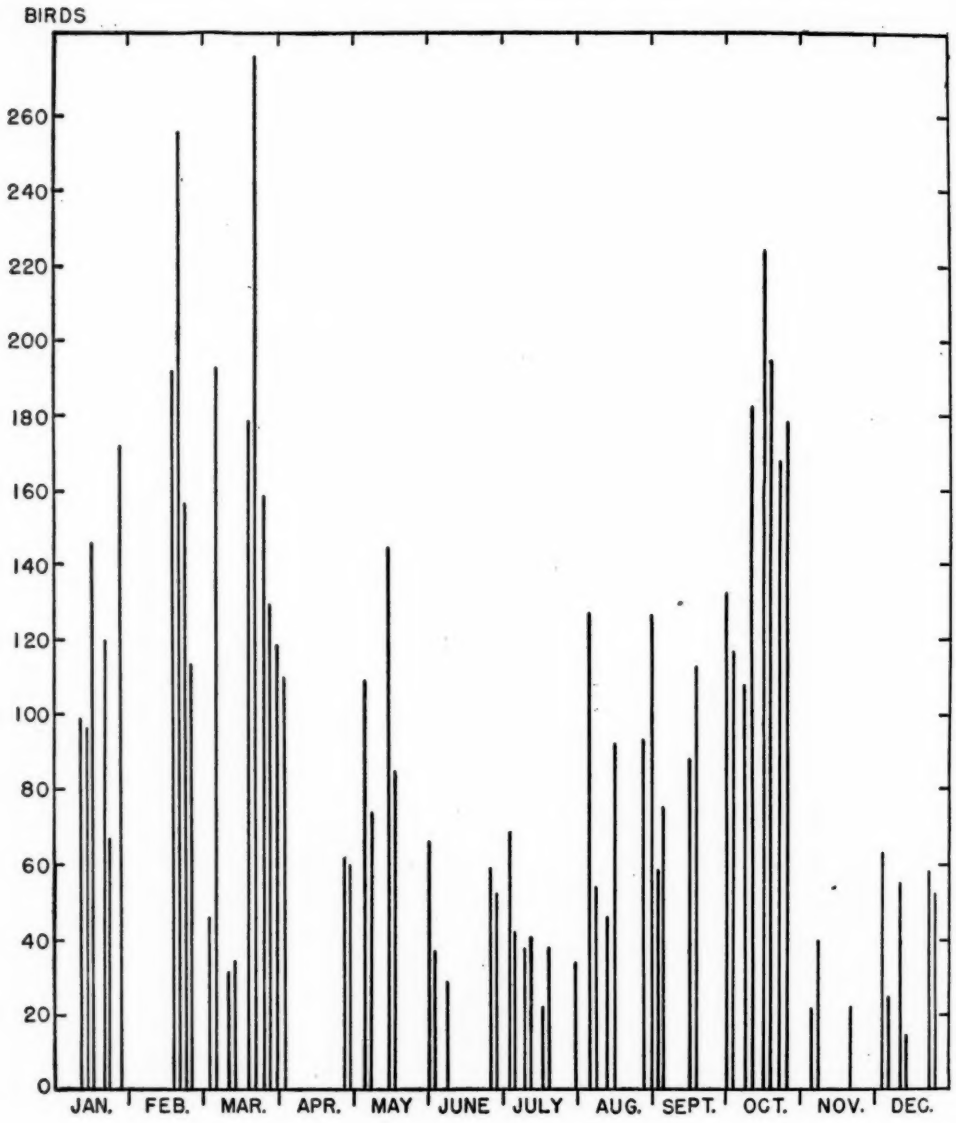

FIG. 2.—Results of all of the morning roadside censuses taken over the same 24.5-mile route in the Hardin area for a period of one year.

an accurate indication of the population density even with ten censuses per month, and the V shows the method to be unreliable. Actually the difference between successive censuses was oftentimes found statistically significant, which, of course, should not be the case. Since the October censuses were made repeatedly it is certain that McClure's statement (1945:45), "The roadside

TABLE 1.—VARIATION IN ROADSIDE CENSUS COUNTS WITHIN SELECTED MONTHLY PERIODS.

	Billings		Hardin	
	March	October	March	October
Number of censuses	8	6	10	8
Range	28 to 103	35 to 203	32 to 276	108 to 222
Mean	58 ± 9	122 ± 22	128 ± 23	163 ± 13
Standard Deviation	25.7 ± 6.5	54.7 ± 16	74 ± 16.5	37.4 ± 9.5
Coefficient of Variation	44.3 ± 11	44.8 ± 13	54.7 ± 12	22.9 ± 6

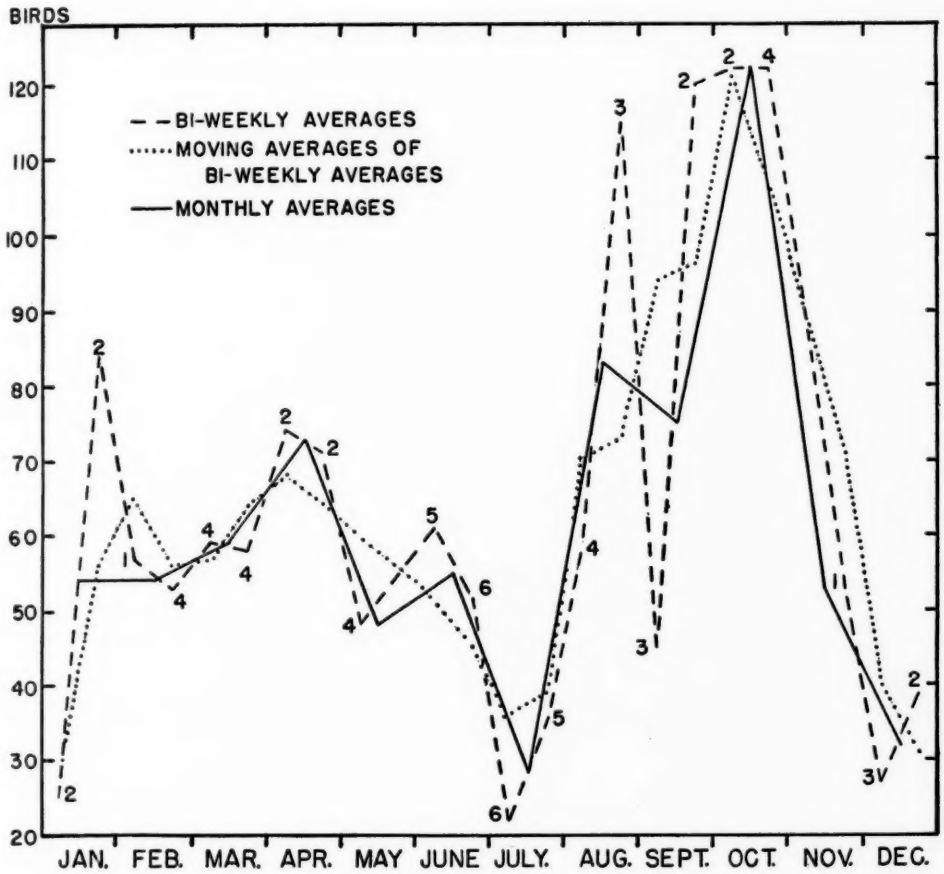

FIG. 3.—Monthly, bi-weekly, and moving averages of bi-weekly averages of all the roadside censuses taken over the same route in the Billings area for a period of one year. The numbers indicate the number of individual censuses combined to compute the average.

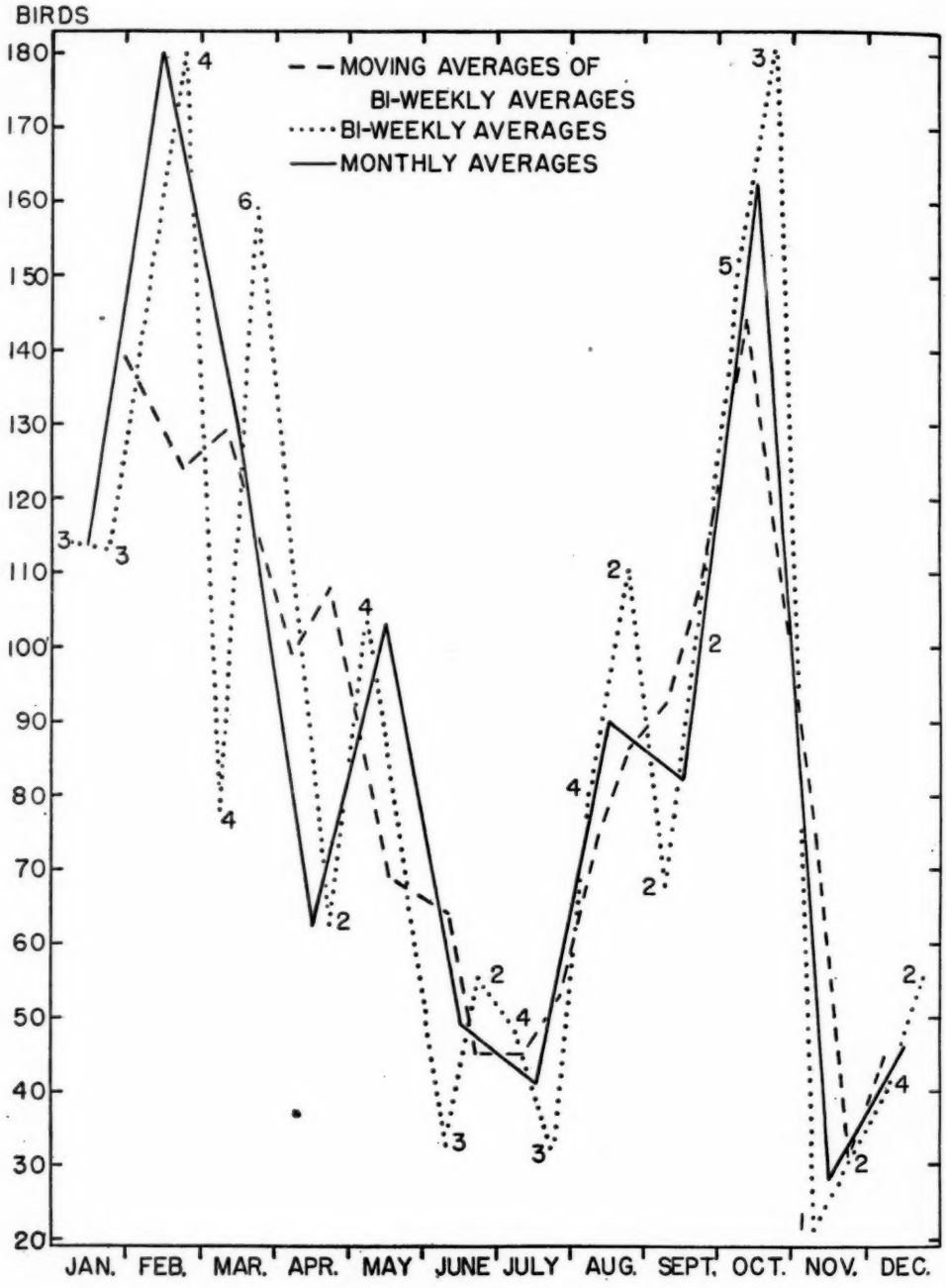

FIG. 4.—Monthly, bi-weekly, and moving averages of bi-weekly averages of all the roadside censuses taken over the same route in the Hardin area for a period of one year. The numbers indicate the number of individual censuses combined to compute the average.

count is best previous to the hunting season, if used repeatedly," may not be applied widely.

An attempt to compensate for anomalies in individual censuses was made by plotting bi-weekly and monthly averages of censuses in both study areas. Bi-weekly averages for the Billings area (Figure 3) show very little consistency at any time during the year. Fluctuations often exceed several hundred per cent in successive periods. It is possible to smooth the curve considerably by using monthly averages, but even then the averages of censuses taken in June and September are out of line with adjacent monthly periods. Inconsistencies in December and early January may be excluded because of hunting season disturbances. A much smoother curve and one indicative of known annual population changes is secured by the use of moving averages based on bi-weekly averages. However, in order to obtain census data which would conform to indices erected by employing moving averages, several successive censuses must be taken over a period of at least six weeks. More time and expense would be involved in such an endeavor than would be required for many other types of censuses which are less fallible but more time- and labor-consuming.

Bi-weekly, monthly, and moving averages based on bi-weekly averages for censuses in the Hardin area show essentially the same fluctuation as in the Billings region (Figure 4). In an effort to discover the causes which underly the extensive variation resulting from the roadside censuses all those factors presumed or known to influence census results, and for which we have data, are analyzed below.

EFFECT OF SEX AND AGE ON THE ROADSIDE CENSUS

Monthly averages of the composition by sexes of the population observed throughout the year over the Billings route are shown in Figure 5. Unsexed birds are either young in juvenal plumage or adults in large flocks observed during the winter. The cock-hen ratio of approximately 1:3 holds until April when the hens begin nesting. Relatively fewer hens are seen from April through August. Young birds (unsexed) first appear in June and comprise by far the greatest proportion of the population in August and September. By September the post-juvenal plumage is present and the sexes are distinguishable, resulting in a sharp decline in the unsexed curve and a sharp incline in the curves of the two sexes. Cocks become somewhat more numerous than hens in October, but this may result from young females being placed in the unsexed category since the cocks and hens would be equal in number if the unsexed were added to the total for the females. As the hunting season opens the sexes are approximately equal, but at the close of the hunting season the hens are about three times as numerous as cocks.

Data from Hardin are more variable, but they agree in general with those obtained in the Billings area (Figure 6). An anomalous increase in the hen population occurred in May. On the basis of the data secured it seems likely that variation due to differences in sexes observed cannot account for the enormous day to day or week to week variation in census results, but these differences are responsible for much of the long-term variation, particularly in the spring and early summer.

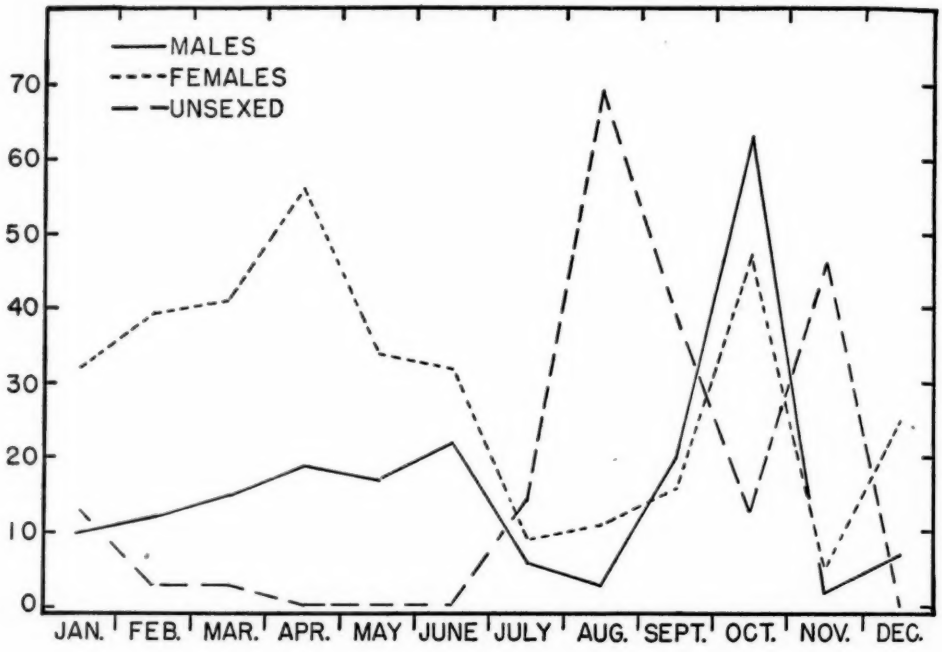

FIG. 5.—Composition by sexes of total number of birds seen throughout the year on the Billings census route.

EFFECT OF WEATHER CONDITIONS ON THE ROADSIDE CENSUS

It was realized early (Bennett and Hendrickson, 1938) that weather conditions affected the movement of the birds in the early morning. As a result counts in Iowa were made for the most part on clear fall days. In testing the validity of this technique the counts in Montana were made during all types of weather, and a careful check was kept on existing physical conditions. A summary of the combined census data from both areas is presented in Table 2. Since the number of censuses made varied for different weather conditions, it was necessary to compute monthly averages of the number of birds seen under each type of weather. The total of averages for each month represents the sum of the averages for each weather condition within that month. In this manner the varying numbers of censuses taken under different types of weather were placed on a comparable basis. The percentages represent the proportion of the total average number of birds observed under that particular weather condition.

Consistently more birds were observed during summer days on which there was a dewfall than on dewless days, particularly is this true if the totals for both clear and cloudy days with dewfall are combined. As long as dew was present, the clearness or cloudiness of the weather had no consistent effect upon the number of birds counted. A marked constancy was noted in the proportion of birds seen on dewless days which were above freezing and

TABLE 2.—PROPORTION OF TOTAL BIRDS OBSERVED UNDER VARYING WEATHER CONDITIONS DURING THE MORNING ROADSIDE CENSUS THROUGHOUT THE YEAR. THE TOTALS AND PERCENTAGES REPRESENT COMBINED DATA FROM THE BILLINGS AND THE HARDIN CENSUS ROUTES.

Month	Total of averages	No dew	Percentage of total Average for month			
			Rain-Snow	Below 32°F.	Clear-dew	Cloudy-dew
January	317	*30.6*	*44.5*	*24.9*	—	—
February	189	—	*59.8*	*40.2*	—	—
March	386	*24.6*	*40.1*	*25.9*	*9.3*	—
April	229	*28.4*	*26.2*	*24.0*	—	*21.4*
May	218	*29.8*	—	*23.7*	*46.8*	—
June	201	*28.4*	*21.4*	—	*30.3*	*19.9*
July	131	*23.6*	*18.3*	—	*27.5*	*30.5*
August	171	*39.2*	—	—	*60.8*	—
September	242	*27.3*	—	—	*36.7*	*35.9*
October	806	*17.9*	*23.4*	*20.4*	*16.4*	*22.0*
November	81	—	*25.9*	*74.0*	—	—
December	128	*49.2*	—	*50.8*	—	—

without inclement weather, except for October through December. During this season winter flocking and hunting contribute toward inconsistent results. Except for November and December (for which we have few data) freezing weather failed to disclose more birds than dewless days. On rainy days or days during which a snowfall occurred more birds were in evidence than on days with freezing temperatures. These data obviously apply only to cover conditions in the area of study. However it is probably universally true that pheasants will delay entering thick heavy cover if it is wet with dew, rain, or snow.

Randall and Bennett (1939:435) summarize their findings by stating, "They [roadside censuses] should be made on clear fall days having normal dew-fall. Rainy, foggy, cloudy, and dewless mornings are not satisfactory times." To compare our results with those secured in Pennsylvania, all censuses made on cloudy, rainy, overcast, or dewless mornings and on mornings soon after a rain or during heavy winds were eliminated. The selected results are presented in Table 3.

TABLE 3.—RESULTS OF MORNING ROADSIDE CENSUSES THROUGHOUT THE YEAR ALONG THE BILLINGS ROUTE. ALL COUNTS ELIMINATED EXCEPT THOSE MADE ON CLEAR DAYS WITH DEW

Date	Total birds	Birds per mile
January 7	30	1.0
January 20	102	3.5
February 17	17	0.4
March 9	36	1.3
March 15	103	3.6
March 22	53	1.8
May 4	59	2.0
May 11	38	1.3
May 12	63	2.2
June 7	109	3.6
June 15	63	2.0
June 22	38	1.8
June 28	50	1.7
June 29	62	2.1
July 6	20	0.7
July 14	15	0.5
July 19	41	1.4
July 24	29	1.0
August 3	95	3.2
August 12	95	3.2
September 11	50	1.7
September 15	50	1.7
September 30	153	5.3
October 7	108	3.7
December 2	5	0.2
December 9	28	1.0
December 17	56	2.0

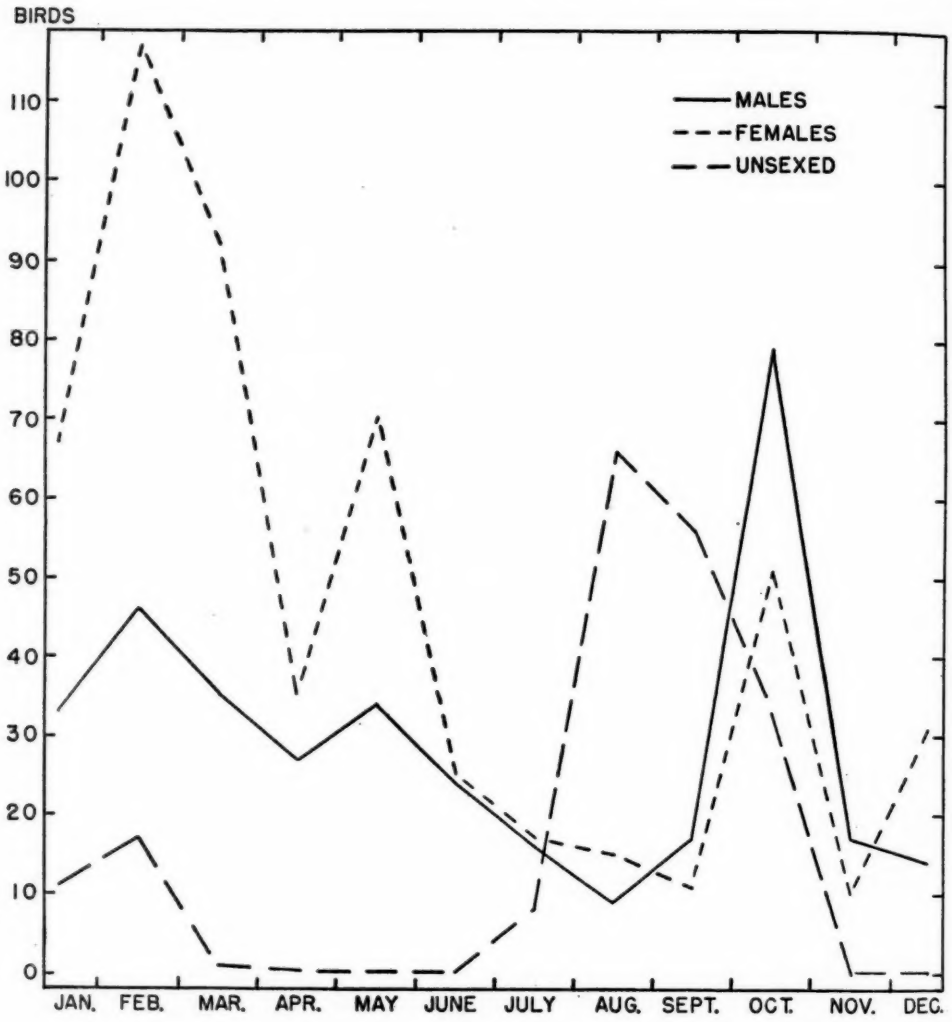

FIG. 6.—Composition by sexes of total number of birds seen throughout the year on the Hardin census route.

It is apparent that the results are inconsistent for short periods and that they fail to show expected yearly variations. Moreover, the variation within brief periods is equally as great as that found when all census counts are considered. Our results, therefore, do not coincide with those published by Randall and Bennett who attribute most of their inconsistent counts to inclement weather.

A closer comparison of our results with those of Randall and Bennett was made by comparing statistically the censuses made under identical weather conditions at the same season (Table 4).

It is apparent that variability in census results is extensive in both Pennsylvania and Montana. A V of 10 is probably within reasonable variable limits in view of the diverse factors operating toward inconsistency in censusing pheasants by the roadside technique.

TABLE 4.—A STATISTICAL COMPARISON OF THE CENSUS DATA PRESENTED BY RANDALL AND BENNETT (1939) FOR PENNSYLVANIA WITH THE CENSUS DATA SECURED IN MONTANA FOR THE SAME SEASON OF THE YEAR. ONLY THE COUNTS MADE ON CLEAR DEWY DAYS ARE INCLUDED.

State	Route	Mean birds per mile	Mean deviation	Standard deviation	Coefficient of variation
Pennsylvania	Lower Macungie	7.12	.73 ± .11	.81 ± .19	11.4 ± 2.7
	Lower Milford	2.50	—	.27	10.8
	Berks County	1.21	.34 ± .07	.35 ± .11	28.9 ± 9.2
	North Whitehall	1.39	.32 ± .08	.40 ± .13	28.8 ± 9.1
Montana	Billings	3.13	—	1.51 ± .44	48.3 ± 13.9
	Hardin	4.93	—	.78 ± .22	15.7 ± 4.5

Censuses on the Lower Macungie and Lower Milford routes in Pennsylvania are certainly at the limit of usefulness, if not beyond. The distribution of data for the former route does not coincide with a normal curve as evidenced by a coefficient of skewness of 0.9. Results from censuses in Berks County and North Whitehall, Pennsylvania, are useless as indicated by the high V. Results from censuses in Montana indicate that even though selection is made for season and particular weather conditions raw census data are much too variable to be relied upon.

The effect of dewfall on the observations of pheasants in the early morning has been specifically noted and considered by Randall and Bennett (1939: 35) and by Hicks, *et al* (1941:8). The former workers did not define the extent of dewfall desired for censusing except to state "normal." It is impossible for other workers to compare objectively such a condition. The latter investigators classified optimum censusing conditions as clear, quiet mornings when there was a heavy dew and relatively little fog. To assess more objectively the relationship between birds seen and the extent of dewfall those of our censuses that were made during temperatures below 32°F, on mornings following rain, or on mornings with heavy winds were eliminated. This left to be counted those censuses made on mild mornings during which dew was or was not present. Dewfall was recorded in four grades—absent, light, medium, and heavy. Bi-weekly means of total birds observed on the census routes under these conditions were computed, and the percentage of deviation of individual censuses from these means was plotted on the Y axis of Figure 7 which illustrates the effect of dewfall on the number of birds observed during morning roadside censuses. Each category of dew condition was assigned a numerical value as follows: no dew (1); light dew (2); medium dew (3); and heavy dew (4). These were plotted on the X axis. The coefficient of correlation (r) was found to be .426 ± .114, and by the test for significance of r it was found that $t = 2.71$ (t for .01 = 2.638). These figures

demonstrate that there is a correlation between the number of birds seen and the amount of dewfall and that this correlation, although quite variable, is highly significant. The regression of Y on X was determined to ascertain the correction factor required to place census results taken on days with some dewfall on an equal basis with those secured on dewless days. These correction factors are indicated in Figure 7. Notwithstanding the highly significant correlation and the resultant extensive correction factors, computation of the prediction index shows that only 9.7 percent of the variability of the censuses may be ascribed to the factor of dewfall. No correlation between the number of birds observed and the temperature was found. When dewfall was plotted against temperature the lack of a positive correlation indicated that humidity data were essential to demonstrate the relationship between these physical factors. However, no numerical data were available for humidity. It is extremely doubtful whether changes in humidity would affect the presence or absence of pheasants except through the coaction of humidity and temperature in producing variable amounts of dew.

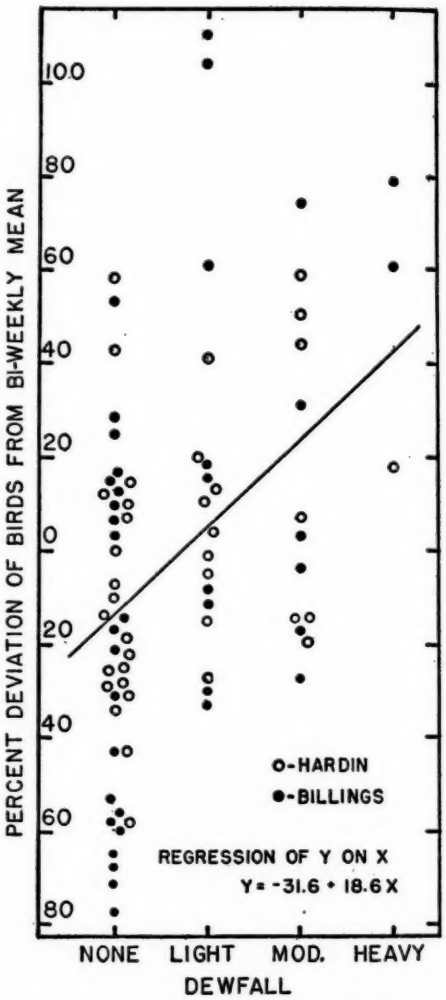

FIG. 7.—The effect of dewfall on the number of birds observed during morning roadside censuses. Counts made on mornings when the temperature was below 32°F., on mornings following a rain, or on mornings with heavy winds were eliminated.

Monthly averages of roadside censuses in the Billings area corrected for varying dewfall conditions were plotted along with the uncorrected monthly averages for this area over the period from April through October (Figure 8). Although with these corrections the curve is straightened slightly during some months, the same inconsistencies obtain and are even augmented in July and September.

An analysis of our data taking into account all those factors known to cause or suspected of causing variation was made. For this analysis only censuses made in the fall months prior to the hunting season were considered, thus eliminating variation attributable

to behavior during the breeding season, winter flocking, effects of the hunting season, and the variability in plant growth in the spring and early summer. Further, counts made on mornings with temperatures below 32°F., with high winds, with rain or immediately following a rain, and with snow on the ground or during a snowstorm were eliminated because these inclement weather conditions may be responsible for variation, the extent of which we were unable to ascertain with the data at hand. The corrections for various conditions of dewfall were made and included in the census figures used for this period. A statistical analysis of these data is presented in Table 5. It is apparent that even two censuses per week over the same route and under almost identical conditions fail to result in indices sufficiently similar to be relied upon.

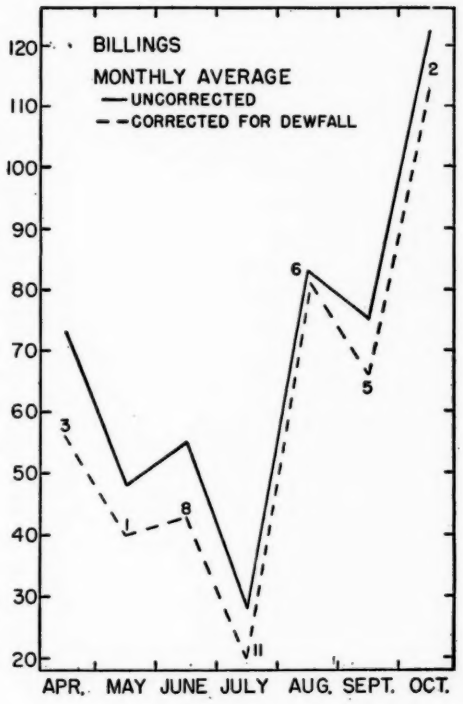

FIG. 8.—Comparison of uncorrected counts with counts corrected for dewfall, based on the data presented in Fig. 7. The numbers indicate the total number of censuses averaged.

EFFECT OF THE PERIOD OF DAILY OBSERVATION

Some observers have found that the number of birds visible varied during the early morning hours (Hicks, *et al.*, 1941:7). In Ohio it was found that most pheasants were seen from 6:30 to 7:10 A.M. The frequency index was found to be 100 for 6:30 to 7:10 A.M., 78 for 7:10 to 7:50 A.M., and 68 for 7:50 to 8:30 A.M. Since these times were not shown in relation to sunrise, it is impossible to compare them with other studies in other areas. To determine whether differences exist in the time of appearance of birds in Montana, a factor which may possibly account for the variabil-

TABLE 5.—STATISTICAL ANALYSIS OF EARLY MORNING ROADSIDE CENSUSES TAKEN IN THE FALL OVER THE BILLINGS AND HARDIN ROUTES. ALL FACTORS FOUND TO CAUSE VARIABILITY IN THE NUMBER OF PHEASANTS OBSERVED HAVE EITHER BEEN ELIMINATED OR CORRECTIONS HAVE BEEN MADE FOR THEM.

Census route	Inclusive dates	Number of censuses	Range in birds per mile	Mean	Standard deviation	Coefficient of variation
Billings	Sept. 11 to Oct. 7	7	1.69–5.87	3.23	1.29 ± .35	39.9 ± 10.7
Hardin	Sept. 16 to Oct. 9	5	2.61–7.02	4.61	1.61 ± .51	34.9 ± 11.0

ity in census results, the total number of birds observed in each 15-minute period from sunrise to 2 hours past sunrise was recorded. The chi-square test (χ^2) was applied assuming that no differences occurred throughout the two-hour census period. That our hypothesis was invalid was shown by the very highly significant evidence against it ($\chi^2 = 562.31$; P for $.01 = 18.5$). Since the total birds seen in the first 15 minutes after sunrise (499) was far out of line with the theoretical total (1,169), this period was eliminated from the subsequent test. The χ^2 test was then applied to the supposition that the total of birds seen in each 15-minute interval is approximately equal from 15 minutes after sunrise to 2 hours after sunrise. Very highly significant evidence against this supposition was also apparent ($\chi^2 = 114.22$; P for $.01 = 16.8$). Since the total birds seen in the interval from 15 minutes to 30 minutes after sunrise (1,063) was somewhat out of line with the theoretical total (1,265), this period was likewise eliminated from consideration in testing the next hypothesis; namely, that the total birds seen in each 15-minute interval from 30 minutes to 2 hours past sunrise is approximately equal. In addition, the period from $1\frac{1}{2}$ hours to $1\frac{3}{4}$ hours was omitted because the total birds seen during this period (1,513) was considerably out of line with the theoretical total (1,265). Although much less variability is shown subsequent to these eliminations, it is evident that highly significant differences do occur ($\chi^2 = 17.32$; P for $.01 = 15.1$). The same test was applied to the data grouped in half-hour intervals covering the period from one-half hour after sunrise to 2 hours after sunrise. The evidence ($\chi^2 = 63.01$; P for $.01 = 9.2$) again was highly significant against the supposition that there was no difference in the time of appearance.

Two important points emanate from the foregoing χ^2 tests: (1) It is apparent that in Montana censusing should not begin until a half hour after sunrise, and (2) some unknown factors are functioning to cause this highly significant variability in the time of appearance of the birds. From the evidence thus presented it is clear that statements made by Randall and Bennett (1939:433) that "The proper time to start the morning counts is at sunrise . . . ," and that ". . . the counts should be discontinued about one and one-half hours after sunrise . . . " are not applicable to the areas we investigated, and further analysis of their data might demonstrate that great variation occurs there also. Since the census results reported by Hicks, *et al.* (1941) were secured by censusing from 6:30 to 8:30 every morning in September, apparently without relation to sunrise, the chances are good that the variability in appearance soon after sunrise introduced considerable error into their records.

In the hope that factors responsible for introducing the variability in appearance during the early morning might be discerned from our data, analyses were made of several possible relationships between the number of birds seen and factors such as weather and season.

Seasonal differences in time of early morning appearance were analyzed by totaling the number of birds observed for each 15-minute interval during the censusing period and plotting the percentage of the total birds that were ob-

served in each interval for each season (Figure 9). In general the birds seemed to appear slightly earlier during the summer and fall than in the winter and spring. However, since the greatest variation is approximately 15 minutes, it is reasonable to assume that the variation in time of appearance of birds in relation to sunrise throughout the year is insignificant.

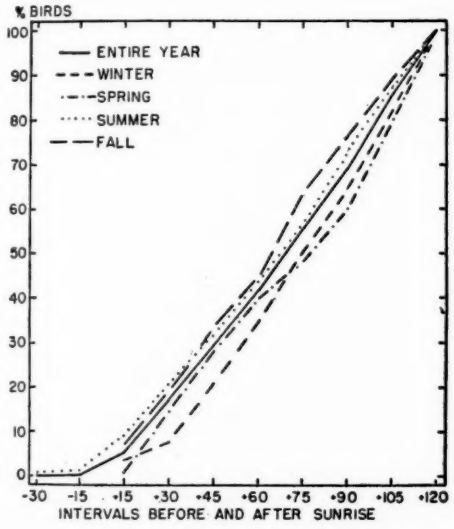

FIG. 9.—Seasonal differences in time of early morning appearance along the census routes for all birds under all conditions. The curves are drawn from cumulative percentages.

Judging from general reactions of birds to weather conditions it would seem plausible to expect that the various types of fair and inclement weather would exert an appreciable effect on the early morning activities of pheasants. Since dewfall has already been shown to affect significantly the total number of birds seen during the census period, an analysis was made of this, and other factors, to ascertain whether or not these weather conditions exerted their influence during any particular phase of the daily census period. The total number of birds observed during each weather condition in the spring in each quarter hour interval from 15 minutes after sunrise to 2 hours after sunrise was computed. The figures for both census areas were lumped and the average number of birds observed during each interval for each weather condition was plotted (Figure 10).

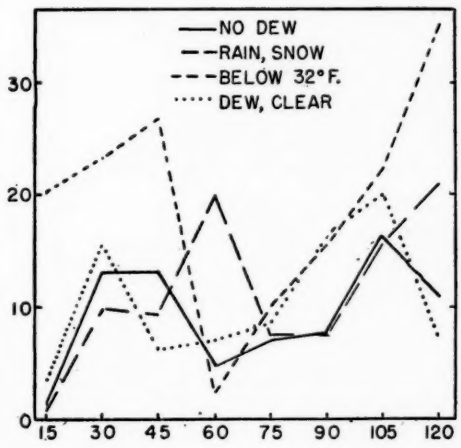

FIG. 10.—Effect of weather on the early morning time of appearance of pheasants along the census routes. The curves represent the average number of birds observed during each interval under certain weather conditions. Only observations during the spring months (March, April, and May) are represented here.

A glance at Figure 10 shows the extremely variable nature of the data and lack of any sustained trends or plateaus in the curves. It is clearly demonstrated, however, that under all weather conditions observations fail to reach the maximum number until ½ hour after sunrise. Since conclusions drawn from variable, combined data of this sort

might reasonably be suspect, we plotted the figures separately for each census area to determine whether differences in terrain might have caused the variable results. These individual curves follow similar patterns which demonstrate the uniformity between the two routes in the relative number of birds seen during the various 15-minute intervals. Thus, the possibility that differences in terrain influenced the census results shown in Figure 10 is ruled out.

Because the fall months prior to the hunting season have been designated as the best time to employ the roadside census technique, the effect of the weather on the early morning appearance of pheasants along the census routes during September and October was analyzed in the same way as that for the spring but plotted separately for each route. Again note (Figure 11) the extreme variation and the lack of sustained trends, and that the curves for the two areas frequently are parallel, but at other times diametrically oppose each other. The complete absence of any established trend in early morning appearance illustrates well the lack of uniformity in the average number of birds observed for each 15-minute interval.

In a final effort to obviate the inconsistencies so prominently set forth in this study on the time of appearance of pheasants in the early morning, virtually all factors discovered to affect census results or even suspected of affecting the results were eliminated, and the χ^2 test was applied to the hypothesis that no differences exist in the time of appearance of birds along the census routes. Factors eliminated include: the winter months, November through February, when the birds are in flocks;

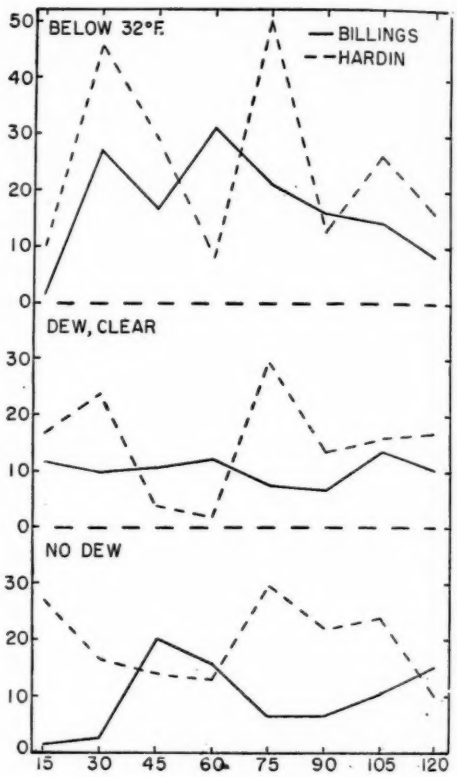

FIG. 11.—The effect of weather on the early morning appearance of pheasants along the census routes during September and October.

the first half-hour's observations after sunrise; and, all counts made on mornings other than those that were clear and dewy. Corrections for dewfall were made. Despite these manipulations very significant differences do occur and the hypothesis was proved to be invalid ($\chi^2 = 28.36$; P for $.01 = 15.1$). When all but dewless days were eliminated very similar results were obtained ($\chi^2 = 25.9$). Randall and Bennett (1939) and Hicks, *et al* (1941) state that the most reliable counts are made on days with "normal" and "heavy" dewfall, respectively. The above data shows less, but probably

insignificantly less, variation on dewless days.

These analyses on the time of appearance of pheasants during early morning hours clearly indicate that some factor or factors are responsible for the measured variability within the census period, but that none of the factors exert a constant or sustained effect on the birds; this is shown by the absence of trends and frequent reversals of high and low average values for successive quarter-hour intervals.

SUMMARY AND CONCLUSIONS

It is apparent that great variation exists in the results obtained in censusing pheasants by the roadside method. Observers do not agree with each other as to specific details of methods or results and oftentimes fail to note the extensive variability prevalent in all studies thus far published.

A comparative study of individual censuses in Montana showed them to be highly erratic and often not in line with known seasonal fluctuations in populations. The same may be said for bi-weekly and monthly averages of censuses. Moving averages of bi-weekly averages show results more in line with known annual population changes, but they involve taking successive censuses over a period of at least six weeks and consequently are more time-consuming and expensive than are other types of less-fallible census techniques. Even within a period of one month the results of individual censuses are often significantly different, and the coefficients of variability are so high that the method is shown to be unreliable.

When the results of counts are plotted by sexes it is observed that various anomalous ratios appear, and the expected seasonal trends are not indicated.

A comparison of the number of birds observed with the varying weather conditions under which they were seen shows that: (1) more birds are found on days with a dewfall than on dewless days; (2) clearness or cloudiness of the weather has little effect; and (3) birds are more in evidence on rainy or snowy days than on freezing days. It is apparent that it is impossible to select any certain type of weather condition as optimal for censusing. A positive correlation was found between the amount of dewfall and the number of birds observed, and a correction factor was computed. However, the prediction index shows that less than 10 per cent of the variability of the censuses can be attributed to variations in dewfall. Making corrections for some factors and eliminating counts made during inclement weather indicated that even two censuses per week fail to produce reliable indices.

Tests to determine the time (within two hours after sunrise) of the appearance of most of the birds demonstrated no constancy, but the first half hour after sunrise is the most variable. Nor was there found any definite effect of weather on the time of appearance.

It is clear that the variability in results secured by the roadside census technique as employed for pheasants is sufficiently great to make conclusions drawn therefrom unreliable. The factors responsible for this variability are apparently complex and probably difficult of measurement. Thus, were one ultimately to discover these causes and to compute the necessary correction factors, it is likely that the number of censuses required for statistical ac-

curacy, in addition to the apparatus and subsequent mathematical manipulation necessary to reduce measured factors influencing variability to useful tools, would involve more man-hours and more highly skilled personnel than is warranted for a game inventory. True, no adequate method which may be applied generally has yet been devised for censusing pheasants, but it appears that attacks on the problem other than by means of the roadside census technique are desirable and promise to provide more accurate results.

LITERATURE CITED

BACH, ROY. N. 1944. North Dakota upland game census for 1944. North Dakota Outdoors, 7(3): 6–8.

BENNETT, LOGAN J. and GEORGE O. HENDRICKSON. 1938. Censuring [sic] the ringneck pheasant in Iowa. Trans. N. Amer. Wildl. Conf. 719–723.

BUSS, I. O. 1946. Wisconsin pheasant populations. Wisconsin Cons. Dept. Publ. 326, A-46: 184 pp.

HIATT, ROBERT W. and HARVEY I. FISHER. The reproductive cycle of ring-necked pheasants in Montana. Auk, (in press).

HICKS, LAWRENCE E., DANIEL L. LEEDY and DON H. STRODE. 1941. The 1941 September pheasant survey. Ohio Wildl. Res. Sta. Release No. 170, 24 pp. [Mimeo].

MCCLURE, H. ELLIOTT. 1945. Comparison of census methods for pheasants in Nebraska. Journ. Wildl. Mgt., 9: 38–45.

RANDALL, PIERCE E. and LOGAN J. BENNETT. 1939. Censusing ringneck pheasants in Pennsylvania. Trans. N. Amer. Wildl. Conf. 431–436.

BAND RETURNS FROM INDIANA CLUB-REARED PHEASANTS[1]

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For many years the Indiana Division of Fish and Game has been engaged in a program of artificially propagating pheasants through the cooperation of the conservation clubs. Many thousands of pheasants have been released in this manner each year; however, little was known regarding the effect of the releases in providing birds for the gun, adaptability of the birds in various sections of the state, period of survival, and causes of mortality. In the summer of 1942, a study was initiated through Pittman-Robertson Wildlife Research Project 2-R in which a portion of the club-reared pheasants would be banded in an effort to uncover these unknown factors.

As the study was to be extensive, arrangements were made to band from one to two brooders of pheasants in each of several counties throughout the

[1] Able assistance in the banding work was given by the following personnel of the Pittman-Robertson Project 2-R: Laurits W. Krefting, Technical Investigator; Wm. B. Barnes, Project Leader; and District Leaders, E. E. Good; A. M. Gosman; J. C. Kase; O. V. Lopp; and W. E. Madden. Additional appreciation is expressed to Mr. Barnes who assembled the data during the author's sojourn in the armed forces. Technical supervision was given by C. Gordon Fredine, Associate in Wildlife Conservation, Purdue University.

state. Even such a broad program represented only a small portion of the total number of artificially propagated birds released. The selection of cooperating conservation clubs was principally confined to small rural organizations having a high percentage of farmer membership and limiting their pheasant releases to small county areas.

A total of 48 cooperating conservation clubs, located in 35 different counties, were chosen for participation in this study. Club officials were contacted in order to acquaint the club membership with the purpose of this study. A complete record was made of each release giving band number, date, name of farm, and location by section, township, and range. Report forms were left with each club secretary for recovery data, including band number, date, name and address of reporter, location of recovery, sex of bird, and cause of death.

The clubs were urged to give the releases all possible publicity, which resulted in varying degrees of action. A few clubs offered prizes, one club had posters printed and displayed throughout the county, and the Publicity Division of the Department of Conservation sent releases to local newspapers in every county in the state, requesting specific information which could be given to the club secretary or mailed directly to the Department of Conservation.

All bands contained a number preceded by the letter "R." This letter distinguished the research project bands and eliminated any duplication with bands previously used by the Indiana Division of Fish and Game. Each band contained the inscription, "NOTIFY DEPT. OF CONSV. INDPLS."

During the period July 13 to August 28, 1942, a total of 8,406 eight-week-old pheasants reared by these conservation clubs were banded and released in the wild.

BAND RETURNS

A total of 367 notifications, representing 4.4 per cent of the total release, were received between July 17, 1942, and December 6, 1943, regarding recovered bands, including both hens and cocks (Table 1). For convenience in the presentation of these data, the state was divided into the following districts: 1, northwest; 2, northeast; 3, central; 4, southwest; 5, southcentral; and 6, southeast.

At the time of release only 1,303 of

TABLE 1.—BAND RETURNS, BY NUMBERS AND PERCENTAGES, FROM 8,406 PEN-REARED PHEASANTS RELEASED BY DISTRICTS IN INDIANA, SUMMER, 1942.

Dist. No.	No. of Clubs Co-operating	Total Banded	Total Returns	Percentages of Total Returns	Total Banded Cocks Bagged	Percentages of Banded Cocks Bagged
1	8	1,355	55	*4.1*	43	*6.3*
2	23	4,610	200	*4.3*	138	*6.0*
3	7	1,074	61	*5.7*	52	*9.7*
4	2	309	1	*0.3*	1	*0.6*
5	3	437	23	*5.3*	15	*6.9*
6	5	621	27	*4.3*	22	*7.1*
Total	48	8,406	367	*4.4*	271	*6.4*

the pheasants were sexed. Of this total 52.9 per cent were determined to be cocks; 45.9 per cent, hens; and 1.2 per cent, questionable. It has, therefore, been assumed that the sex ratio of the entire number banded was 1:1. Using this assumed ratio, 4,203 cock birds were released. Information was received regarding 271 banded cocks, or a statewide return of 6.4 per cent. Olds (1941) had a 7.9 per cent return from 11,012 immature cocks released in July and August in Ohio.

The return for northern Indiana was 6.6 per cent as compared with 5.6 per cent for the southern part of the state. The lower percentage for the southern section was due primarily to the poor return from the Wabash Valley. The corn hog belt, located in the southern half of northern Indiana where intensive farming is practiced, had a return of nearly 10 per cent. The highest gun pressure occurs there.

TABLE 2.—BAND RECOVERY PERIODS DURING 1942–1943 FOR 366 PEN-REARED PHEASANTS BY DISTRICTS IN INDIANA.

	Mortality Period				Period in the Wild								
District number	Pre-hunting season	Open season kill	Post-hunting season	Second year	One day	1 to 7 days	1 to 4 weeks	1 to 2 months	2 to 3 months	3 to 4 months	4 to 5 months	5 months to 1 yr.	Over one year
1	9	45	3	0	0	2	5	3	11	34	0	2	0
2	51	142	4	2	4	20	8	5	15	137	5	3	2
3	3	52	2	3	0	0	0	2	28	26	1	0	3
4	0	1	0	0	0	0	0	0	0	1	0	0	0
5	9	14	0	0	0	4	0	4	13	2	0	0	0
6	4	22	0	0	1	0	2	1	5	17	0	0	0
Total	76	276	9	5	5	26	15	15	72	217	6	5	5

MORTALITY PERIODS

Mortality periods were determined for 366 of the total 367 band returns. These were placed in 4 divisions: namely pre-hunting season, open hunting season, post-hunting season, and second year.

Of the total returns, 20.8 per cent were for the pre-hunting season between the time of release and November 10, 1942. During the first 4 weeks following release, 60.5 per cent of the returns for the pre-hunting season were recorded, while the remaining 39.5 per cent covered a period of from 1 to over 2 months in the wild (Table 2). Of the first month's returns, 67.4 per cent of the bands were recovered during the initial 7 days.

The returns for the open hunting season represented 75.4 per cent of the total bands recovered. During this period, however, 5 mortality cases were due to other causes than hunters. Considering the various periods in the wild, hunter returns composed 79.2 per cent of the 2 to 3 month class; 100 per cent of the 3 to 4 month class; and 33.3 per cent of the 4 to 5 month class.

Of the 9 bands recovered during the post-hunting season, 4 of the birds were in the wild from 4 to 5 months and 5 from over 5 months to 1 year. The post-hunting season returns represented only 2.5 per cent of the total band recoveries.

Second year mortality occurring in the summer and fall of 1943 represented 1.4 per cent of the total return. One hen, having a brood of from 12 to 14 young was killed by an automobile during the summer, while another pheasant of unknown sex met the same fate in October. During the 1943 open season, one cock was killed by a school bus and one by a hunter. In the month of December, a pheasant of unknown sex was found dead from an undetermined cause. The last 3 mentioned birds were all originally released by the same conservation club, indicating the possibility of above normal survival in that vicinity.

Basing the returns on the month of release and assuming a 1:1 cock-hen ratio, 2,481 cocks were banded during the 3-week period in July. From this number, 139 returns were subsequently received giving a recovery of 5.6 per cent (Table 3). During the 4-week period in August, a release of 1,722 cocks resulted in 132 returns or 7.7 per cent.

TABLE 3.—NUMBER AND PERCENTAGE OF PEN-REARED COCKS BAGGED BY PERIOD OF RELEASE.

Period	Number Cocks Banded	Number Cocks Bagged	Per Cent of Cocks Bagged
7/12–7/18	314	20	*6.4*
7/19–7/25	1,173	77	*6.6*
7/26–8/1	994	42	*4.2*
8/2–8/8	806	60	*7.4*
8/9–8/15	636	46	*7.2*
8/12–8/29	215	22	*10.2*
8/23–8/29	65	4	*6.2*
Total	4,203	271	*6.4*

CAUSES OF MORTALITY

Mortality records were collected over a period of 16 months. No comparison will be made of mortality by sex as it was very difficult to obtain this information with the exception of pheasants killed by hunters.

In percentages, hunters accounted for 73.8 per cent; accidents for 14.2 per cent; predators for 6.3 per cent; and miscellaneous and unknown causes for 5.7 per cent of the known deaths (Table 4). The return by hunters is proportionately higher due to the difficulty of recovering bands from birds dying from other causes.

Accidents ranked in importance next to the kill by hunters. Of the 52 deaths, 41 were caused by automobiles; 6 by accidents at the time of release; 4 by trains; and 1 by a soybean combine.

Cats and dogs accounted for 60.9 per cent of the known deaths due to predators. Some of these deaths resulted from releases made too close to farm buildings.

Four of the five deaths, due to miscellaneous causes, were attributed to inability of the young pheasants to adjust their diet to wild foods. A boy killed the fifth bird with a stone.

DISTANCES TRAVELED

It was possible to determine the air line distances traveled from the release point by 325 of the pen-reared pheasants. A total of 36 or 11.1 per cent of this group was recovered on the release farms (Table 5). It was found that 29.8 per cent were taken at distances from $\frac{1}{4}$ to 1 mile; 38.2 per cent from over 1 to 5 miles; and 20.9 per cent over 5 miles

TABLE 4.—CAUSES OF MORTALITY OF 367 PEN-REARED PHEASANTS RELEASED BY DISTRICTS IN INDIANA, SUMMER 1942.

Dist. No.	Hunter	Accident	Fox	Dog	Cat	Unknown Mammal	Hawk	Misc.	Unknown	Total
1	43	7	1	0	1	0	0	0	3	55
2	138	31	0	5	7	3	4	5	7	200
3	52	7	0	0	0	0	0	0	2	61
4	1	0	0	0	0	0	0	0	0	1
5	15	3	0	0	1	0	1	0	3	23
6	22	4	0	0	0	0	0	0	1	27
Total	271	52	1	5	9	3	5	5	16	367

from the release point. Of those traveling over 5 miles, 46 traveled from over 5 to 10 miles; 18 from over 10 miles to 20 miles; and 4 traveled over 20 miles. In the last mentioned group, a hen traveled 24 miles and a cock 97 miles.

Four pheasants, banded and released in counties adjoining the state line, were shot out of the state. Three were bagged in Michigan and 1 in Ohio. All had traveled less than 10 miles from the release point.

Other interesting records involve one 8-week-old pheasant that traveled 5 miles in 4 days, and 2 pheasants from the same brooder, but released 4 miles apart, that were shot in the same field.

DISCUSSION

Many bands were undoubtedly recovered by persons who did not report the kill, or passed the band or band recovery information on to others who inadvertently neglected to turn in the record. Whatever this unknown factor may be, it is believed that it represents a number appreciably below that of the total returns.

The survival of 8-week-old pheasants produced by natural propagation is not known; although Leopold, et al. (1943), imply that a mortality of 84 per cent occurs between hatching and the first winter. Randall (1941) found that juvenile mortality from hatching to 10 weeks of age, represented a loss of 12.4 per cent of the naturally produced pheasants on a study area in Pennsylvania.

A high rate of mortality occurs during the pre-hunting season but due to the difficulty of recovering bands, it is

TABLE 5.—DISTANCES TRAVELED FROM RELEASE POINTS BY PEN-REARED PHEASANTS RELEASED BY DISTRICTS IN INDIANA, SUMMER 1942.

Dist. No.	Release Farm	¼ to ½ Mi.	½ to 1 Mi.	1 to 2 Mi.	2 to 3 Mi.	3 to 5 Mi.	5 to 10 Mi.	Over 10 Mi.
1	4	2	4	6	8	8	8	3
2	21	21	39	27	24	22	24	10
3	7	5	10	5	7	3	9	3
4	0	1	0	0	0	0	0	0
5	4	0	11	2	1	1	2	1
6	0	0	4	3	1	6	3	5
Total	36	29	68	43	41	40	46	21

impossible to make an evaluation. In this connection, it is interesting to note that in an Indiana study of survival of adult chukar partridges, J. C. Kase was able to identify 40 cases of predation by fox soon after release. Only 11 bands, involving 27.5 per cent of the known predation cases, were recovered.

From the standpoint of providing birds for the gun only, the release program provided a larger bag in the central portion of the state. This was probably due to a combination of poorer habitat and higher gun pressure. The study would also indicate that the shorter the period of time between release and the open season, the higher the kill. Olds (1940) found the same to be true in Ohio as well as other workers in Michigan and elsewhere.

SUMMARY

During the period between July 13 and August 28, 1942, a total of 8,406 pheasants, pen-reared by 48 conservation clubs, were banded and released at 8 weeks of age in 35 different counties in Indiana.

A total of 367 band returns were received between July 17, 1942, and December 6, 1943, representing 4.4 per cent of the total release. Assuming an equal cock-hen ratio, the returns for 271 cocks represented 6.4 per cent of the total cock pheasants released.

Band returns, in accordance with time released, revealed that 2,481 pheasants released during the period in July resulted in a return of 5.6 per cent, as compared with a return of 7.7 per cent for 1,722 pheasants released in August.

Based on seasonal periods, return percentages were: pre-hunting season, 20.8; open hunting season, 75.4; post-hunting season, 2.5; and second year, 1.4.

Distances traveled by 325 pen-reared pheasants between the points of release and recovery were as follows: 11.1 per cent recovered on release farms; 29.8 per cent at distances from $\frac{1}{4}$ to 1 mile; 38.2 per cent at distances over 1 mile to 5 miles; and 20.9 per cent over 5 miles.

Causes of mortality were 73.8 per cent by hunters; 14.2 per cent by accidents; 6.3 per cent by predators; and 5.7 per cent due to miscellaneous and unknown causes.

LITERATURE CITED

LEOPOLD, ALDO, THEODORE M. SPERRY, WILLIAM S. FEENEY, and JOHN A. CATENHUSEN. 1943. Population turnover on a Wisconsin pheasant refuge. Journ. Wildl. Mgt., **7**:(4) 383–394.

OLDS, HAYDEN W. 1940. Ohio pheasant banding results 1930–1939. Ohio Div. of Consv. and Nat. Res. Bul. 191, pp. 1–44.

1941. 1940 pheasant band returns. Ohio Div. of Consv. and Nat. Res. Bul. 191A, pp. 1–12.

RANDALL, PIERCE E. 1941. The life equation of the ringneck pheasant in Pennsylvania. Trans. N. Am. Wildl. Conf., **5**: 300–320.

HUNTING AS A LIMITATION TO MICHIGAN PHEASANT POPULATIONS

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It is a common conception among laymen, and also among game technicians, that hunting is an important limitation to the numbers of practically all small game animals. The gun is almost universally accepted to have been the cause of reducing or destroying many species in the past, and wherever a game scarcity occurs pressure immediately develops for measures to mitigate the effectiveness of the hunter. From all sides writers and organizational resolutions are warning the sportsman that he must stop short of the limit kill to preserve "seed stock" and reminding him that if he would shoot creatures off the land then he must replace them by paying for large-scale restocking.

Where heavy shooting actually has contributed to a reduction of game, as is indicated in the present waterfowl decline (Day 1946), few would disagree that the annual harvest must be curtailed. Evidence is accumulating, however, that among our small upland species excessive kills are not the common occurrence that is ordinarily assumed. In Michigan it has become evident that relatively high hunting season crops can be taken repeatedly as long as conditions favorable to high breeding productivity are maintained. In other publications I have shown that cottontails can sustain and replace hunting losses of more than half of their numbers (1938) and that a 40 per cent kill of fox squirrels is not too great a share for the hunter (1943). The data presented here should demonstrate that under conditions which are widespread in southern Michigan the ringneck pheasant also can support extremely heavy hunting of male birds without depletion of the breeding stock.

It is generally true that game animals possess a breeding potential sufficiently high to stock any given habitat far beyond its carrying capacity. The result is that each breeding period sees a production considerably above the number of animals which the range can support through less favorable seasons. The "surplus" thus created will inevitably be eliminated in one way or another, and it is likely that with many species a very high percentage of it can be converted to the game bag. The taking of such a harvest should not impair the production of next year's crop and, in fact, may in some cases be beneficial through the reduction of competition for life necessities within the species (Allen 1943, p. 338).

It is with this concept that we can define "overhunting" as any shooting which results in a reduction of the

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[2] Information and conclusions in this paper are based primarily upon studies under Federal Aid in Wildlife Restoration projects Michigan 2R and 7R of the U. S. Fish and Wildlife Service. These studies were a part of the program of the Rose Lake Wildlife Experiment Station of the Game Division, Department of Conservation.

numbers of *effective* breeders and a lower population in the following year. This idea may be almost a platitude with many biologists, but it is contrary to a very popular assumption that all hunting to some extent restricts next year's population and that the elimination or reduction of shooting will be followed by a build-up of numbers. During the war there were widespread irresponsible reports that, with many guns shelved for the duration, game animals were multiplying unchecked and attaining new levels of abundance. When every animal shot is considered to be one less breeder, it is not difficult to understand the compulsion felt by many hunters to replace the hunting kill, at least in part, via artificial restocking.

SOURCE OF DATA

The information used here is principally from two sources. The Rose Lake Wildlife Experiment Station (Allen 1940), a tract of approximately 1,700 acres, has been heavily hunted since the fall of 1939. Individual compulsory report cards are filled out by all hunters, who are required to check in and out at the headquarters. Animals shot are examined in the laboratory. No effort has been made to limit hunting, and hunters have been free to choose the part of the area where they spend their time. There are no restrictions other than the state regulations applicable in all of southern Michigan.

The Prairie Farm in Saginaw County (Burroughs and Dayton 1941) is approximately 8,400 acres in extent and was hunted under a permit system from 1937 to 1944. A pheasant study on this area was made successively by G. A. Ammann, Thomas L. G. Osmer, and Charles Shick (1942), to whom thanks are due for the use of kill figures.

PHEASANT POPULATIONS AT ROSE LAKE

Fall pheasant populations at the Experiment Station are calculated by a method utilizing the known kill and the difference in pre- and post-hunting sex ratios (Allen 1942b.) Table 1 gives observed sex ratios and computed population figures for the years 1940 through 1945. The greatest weakness in this method is the difficulty of securing accurate ratios. In particular, post-season figures have been subject to unaccountable variation, and at present we are using the relative numbers of cocks and hens seen by hunters in the last eight days of the season. Usually only about 10 per cent of the total kill is taken during this period, and the resulting ratio is considered to be reasonably accurate. Of course, the lower the population and the fewer the number of flushes, the more error can be expected. In Table 1 the population figure for 1944 probably is high, but we know of no way to correct this, as very little field work was done at the station during that year.

Figure 1 is a graphic representation of the kill in relation to hunting pressure and the pre-season population of cocks. The years 1939 through 1942 were favorable to the pheasant. Precipitation during the nesting season was not excessive, and temperatures during this period were consistently above the average (Table 2). In 1939, 1940, and 1942 we had the kind of pheasant production which probably can be expected in this land type in an ordinary favorable year. Such production is largely a matter of breeding season success, and

TABLE 1.—CALCULATED PHEASANT POPULATIONS FOR 1940–45 AT ROSE LAKE WILDLIFE EXPERIMENT STATION.

	1940	1941	1942	1943	1944	1945
Pre-season population						
Cocks	21.0	30.6	20.5	11.3	17.9	6.3
Hens	22.6	23.9	22.5	10.5	16.7	8.9
Total	43.6	54.5	43.0	21.8	34.6	15.2
Post-season population						
Cocks	9.7	7.4	6.3	2.8	9.1	3.0
Hens	22.6	23.9	22.5	10.5	16.7	8.9
Total	32.3	31.3	28.8	13.3	25.8	11.9
Statistical Basis for Calculations						
Opening day sex ratio (♂♂: ♀♀)	93.100	128:100	91:100	108:100	108:100	71:100
Cocks killed per 100 acres	10.2	17.4	11.3	6.9	6.8	2.8
Cocks crippled per 100 acres	1.1	5.8	2.9	1.6	2.0	.5
Total kill per 100 acres	11.3	23.2	14.2	8.5	8.8	3.3
Sex ratio for last 8 days of season	43:100	31:100	28:100	27:100	55:100	34:100
Percentage of cocks surviving	46.2	24.2	30.7	25.0	50.9	47.9
Percentage of cocks killed	53.8	75.8	69.3	75.0	49.1	52.1

the numbers of birds were much the same in these three years. The series was interrupted in 1941 by a year which was exceptionally favorable for hatching and survival of young. The population and kill were up conspicuously. It is not possible to say exactly what factors made the difference, but the month of July was exceptionally dry and precipitation was less than normal during May and June.

In 1943 a succession of three unfavorable years began. The most obvious variable to which this could be attributed was weather. That it was not a result of heavy shooting is evident from the fact that the population was at its highest point after two years of extreme hunting pressure and the reduction did not come until the fifth year of these conditions. It is now known that the decline at Rose Lake was a part of a widespread drop in numbers over most of the pheasant's range (Carlson 1946, Perry 1946). In states as widely separated as Minnesota and New York (*op. cit.*) this phenomenon was ascribed to unfavorable weather conditions in the hatching and rearing season.

The most significant weather data for seven years are given in Table 2. The first markedly unfavorable conditions developed in May 1943 with 6.52 inches of precipitation for the month. This compares with a normal of 3.42. Heavy rains on the last two days of the month induced a flood stage in streams and marshes around the study area, and immediately afterward hens were again conspicuously associating with cocks. During the last half of May few hen pheasants had been seen with cocks, and their reappearance may indicate a large nest loss during the high-water period. This observation is particularly noteworthy in the light of a statement by Carlson (1946) as a result of work in Minnesota: "Studies in this area revealed that of the 59 hen pheasants seen shortly after the rains, none had broods and their wholesale association with roosters paralleled sights and

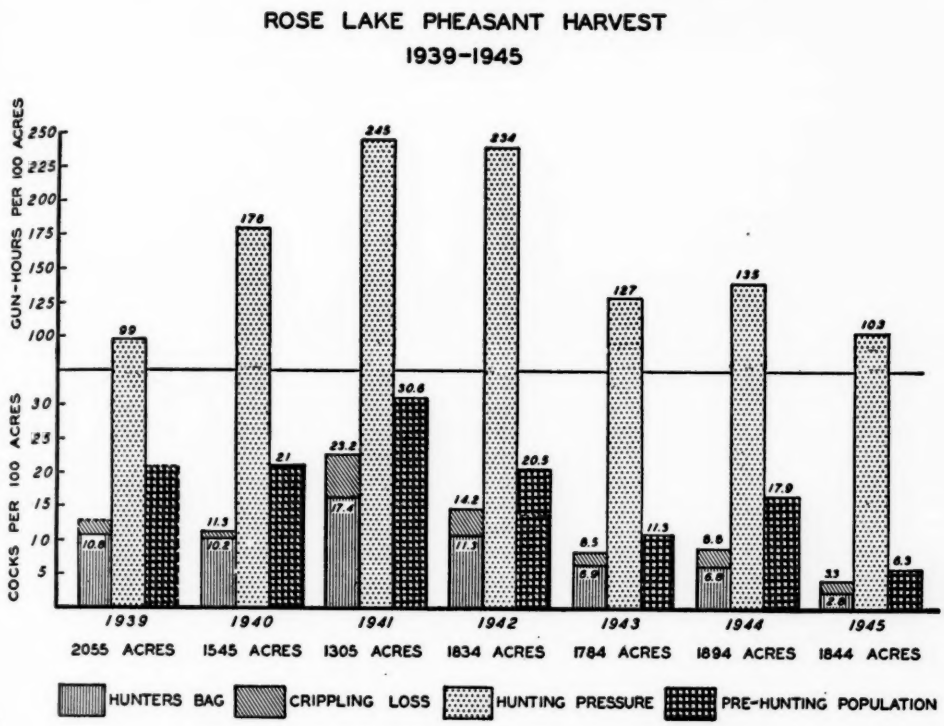

FIG. 1.—This representation of Rose Lake hunting data illustrates lack of direct correlation between hunting pressure and annual kill. With comparable populations the years 1939, 1940 and 1942 showed closely comparable kills, even though a wide divergence existed in the amount of shooting done. The population figure for 1944 probably is high, but there is no satisfactory way of correcting it. Crippling loss for 1939 is not known, so an arbitrary figure of two birds per hundred acres was added to the known kill of 10.8. The population for that year could not be calculated on the same basis as the following seasons, but census drives gave the same figure for 1939 and 1940. Hence the 1939 population level is here represonted as equal to the known level for 1940.

conditions so common in early spring."

In 1944 precipitation at Rose Lake was 5.7 inches for the month of May. In East Lansing nine miles away it was 4.36. Heavy rains on May 17 and 21 were measured at 1.17 and 1.13 inches respectively in East Lansing for the 24-hour periods. This caused local flooding of lowlands, but there is no exact information as to how the condition affected pheasant populations. The remainder of the spring appeared to be favorable, but a poor hatch resulted. The age ratio in the fall kill was conspicuously low in young birds (Table 3). Conditions were better in 1944 than in either the preceding or following year, although personnel and field work were much reduced in that year and less exact information is available. It is believed that the calculated pre- and post-season pheasant populations (Table 1) are erroneously high owing to an artificially high proportion

TABLE 2.—CLIMATOLOGICAL CONDITIONS DURING HATCHING AND REARING SEASON.

	1939	1940	1941	1942	1943	1944	1945	Normal
May								
Total precipitation	2.07	4.66	3.28	4.60*	6.52*	5.70*	7.21*	3.42
Most precip. in 24 hrs.	.52	.97	.66	1.18	1.99	1.46	2.24	
Days of precip.	8	20	10	13	19	14	19	
Thunderstorms	6	6	6	5	4	10	5	
Mean min. tem. (F)	48.8	45.3	48.9	48.5	46.1	51.3	41.1	45.7
June								
Total precipitation	3.77	5.70	3.70	4.48	3.85	2.50	3.70	3.51
Most precip. in 24 hrs.	1.24	2.02	1.56	1.84	2.03	1.14	1.42	
Days of precip.	16	14	11	14	10	10	14	
Thunderstorms	12	13	6	6	11	7	7	
Mean min. temp. (F)	58.0	57.3	58.5	57.4	60.1	58.1	52.6	55.2
July								
Total precipitation	1.60	1.84	.80	4.33	3.87	1.30	2.08	3.10
Most precip. in 24 hrs.	1.23	1.25	.27	.90	1.40	.48	1.31	
Days of precip.	5	9	7	11	8	5	11	
Thunderstorms	3	8	7	8	7	5	9	
Mean min. temp. (F)	59.9	60.4	60.8	60.6	60.2	58.7	57.1	59.3
Total precipitation	7.44	12.20	7.78	14.06	15.70	7.89	13.20	
Breeding success	good	good	excellent	good	poor	poor	poor	

* From Soil Conservation Service weather station at Rose Lake. Other records are from the East Lansing station of U. S. Weather Bureau 9 miles from Rose Lake.

of males in the post-hunting sex ratio.

The year 1945 was the poorest yet observed for pheasants at Rose Lake.[3] Precipitation in May was more than twice normal, and the mean minimum temperature was 4.6 degrees below normal. Only once before in seven years had the temperature for this month dropped below normal and then only by .4 degree in 1940. In one 24-hour period 2.24 inches of rain fell. Errington and Hamerstrom (1937) concluded from their Iowa studies that nests begun previous to the middle of April or after the middle of June were of little consequence in producing pheasants. Their data indicated that nests begun in the second half of May were most productive. This is the period that was most adversely affected by excessive rainfall and precipitation at Rose Lake. Hamerstrom (1936) found that 5.8 per cent of the Iowa pheasant nests studied by him in 1933 through 1935 (a dry period) were destroyed by flooding. Under the conditions described for Michigan, flooding by puddle formation or the actual inundation of lowlands probably was of much greater importance. Excessive rainfall, especially when coupled with low temperatures, would also be expected to occasion losses among newly-hatched chicks. The kill in 1945 was only about 25 per cent of what we are provisionally considering to be "normal" for this area (10 to 12 birds per hundred acres), and population calculations also show a decline of this order (Table 1).

[3] Late information gives a kill of 2.8 birds per hundred acres in 1946—exactly equal to the hunting harvest in 1945.

It is evident that during all three of these years the lowered pheasant population on this area was a result of the failure of the breeding stock to produce an adequate crop of young. This is particularly well illustrated by the figures on age ratios. Table 3 gives the age ratios among pheasants killed at Rose Lake and in the immediate vicinity from 1940 through 1945. The years up to 1943 form a well-defined group and the remaining years another. The proportion of juveniles in the Rose Lake kill showed a marked decline in 1943 and 1944, when about one cock in four was an old bird.[4] There is no doubt that the same condition prevailed in 1945, although the figures are too small to demonstrate it. It seems justifiable to conclude that the smaller proportion of young cocks in the annual kill resulted from a reduction of the size of the new generation of birds, which accounts for the smaller total population.

In discussing age ratios it will be profitable to point out a trend illustrated in Table 3. The proportion of juveniles in the kill declines through the season. This probably indicates an early-season superiority of old cocks over young of the year in the ability to escape hunters. Men handling birds in the laboratory have been impressed with the fact that the largest, oldest cocks are usually brought in late in the season after the bulk of the young and presumably less experienced individuals have either been shot or "educated" to hunting conditions.

TABLE 3.—HUNTING SEASON AGE RATIOS (ADULTS:JUVENILES) OF PHEASANTS AT ROSE LAKE.*

	First day		First week		Second week		Third week		Season	
	Numbers	Ratio	Numbers	Ratio	Numbers	Ratio	Numbers	Ratio	Numbers	Ratio
1940	2:44	1:22	6:113	1:19.8	2:35	1:17.5	2:15	1: 7.5	10:163	1:16.3
1941	3:71	1:24	13:174	1:13.4	5:38	1:8	1:14	1:14	9:226	1:12
1942	3:58	1:19	12:148	1:12.4	6:29	1:5	0:12	—	18:189	1:10.5
1943	7:14	1:2	20:60	1:3	9:22	1:2.6	1:8	1:8	30:90	1:3
1944	7:24	1:3.4	14:48	1:3.4	6:7	1:1.2	8:17	1:2.1	28:72	1:2.6
1945	1:23	1:23	5:37	1:7.4	0:5	—	0:0	—	5:42	1:8.4

* Last 8 days of 22-day season (Oct. 15–Nov. 5).

At Rose Lake an age ratio in excess of 1:10 is to be expected in a favorable year. In 1940 a total of 766 cock pheasants were examined by members of the station staff at road blockades established by the Field Administration Division. In this series 67 were old cocks (a year and a half or older) and 699 were young of the year. The age ratio in this sample of pheasants from a large region in southeastern Michigan was 1:10.4. At the Prairie Farm age ratios have run consistently higher to young pheasants than the Rose Lake figures (Table 4). The reason for such a difference is not clear, but data from all sources indicate that the pheasant is subject to a large yearly turnover.

[4] Methods used in aging these birds were described by Linduska (1943).

Leopold, Sperry, Feeney, and Catenhusen (1943) found that in a pheasant population protected from shooting the shrinkage between winters was approximately 70 per cent and that by the third year only 9 of an original 100 would be alive. Buss (1946) made a similar study on another Wisconsin refuge area and found an even more rapid rate of turnover, probably due to the fact that the tract was of smaller size and therefore more affected by shooting in the area around it. Turnover was complete in these two studies in five and four years respectively. It is evident from age ratios that at Rose Lake the heavily-shot population is replaced to an even greater extent each year.

TABLE 4.—HUNTING SEASON AGE RATIOS AT PRAIRIE FARM.

	Numbers			Ratio
	Ad	Ju	Total	Ad:Ju
1940	73	982	1,055	1:13.4
1941	71	1,659	1,730	1:23.4
1942	72	1,353	1,425	1:18.8
Total	216	3,994	4,210	1:18.5

HUNTING PRESSURE AND ANNUAL KILL

When the Rose Lake station was first opened to hunting in 1939, permits were issued and kill reports kept by persons living in the various farm houses on the area. Several neighbors also coöperated in this way. After that year all permits were issued at the headquarters and all game was examined in the laboratory.

In the fall of 1940 it was evident that we would need some criterion for judging the relative intensity of the hunting pressure on this area. The obvious need was to determine the extent of hunting on private farms. To this end a survey was made in 1940 of farms in the region surrounding Rose Lake. A total of 250 farmers were interviewed by station personnel[5] and asked to keep kill records on forms provided for the purpose. At the close of the season the kill records were collected and summarized. Of the original 250 a total of 136 were considered sufficiently complete and accurate to be used. It was found that these farms, representing 17,935 acres within 20 miles of Lansing in better-than-average pheasant territory, were hunted to the extent of 43 gun-hours to the hundred acres. Since 1940 can from most standpoints be considered a typical pheasant year, these figures should be fairly representative. From this work we can estimate that the average farm in good pheasant range in this state probably is hunted between 40 and 60 gun-hours per hundred acres during the 22-day season.

Table 5 summarizes the hunting pressure and kill for Rose Lake and the Prairie Farm in the years for which data are available. It is evident that hunting pressure on these controlled areas has been very high as compared with the known figures for private farms. Particular attention should be called to the kill in the years 1939 through 1942. On each area productivity was relatively the same for the three years previously cited as "average," and 1941 was definitely a year of high population and yield. These two tracts, which are approximately 35 miles apart, exhibited the same trends, although the Prairie Farm is the more productive of pheasants. This would be expected from the

[5] This survey was made by D. F. Switzenberg, W. W. Shapton, P. S. Baumgras, C. T. Black and J. P. Linduska.

TABLE 5.—ANNUAL KILL AND HUNTING PRESSURE PER HUNDRED ACRES.

	Rose Lake		Prairie Farm	
	Cocks killed	Gun-hours	Cocks killed	Gun-hours
1937			7.3	96
1938			14.8	168
1939	10.8	99	15.6	256
1940	10.2	176	13.0	179
1941	17.4	245	20.6	199
1942	11.3	234	16.9	206
1943	6.9	127	12.6	125
1944	6.8	135	17.6	183
1945	2.8	103	9.2	91

fact that pheasant densities in Michigan, as in most of the bird's range (Leedy 1939, Bennett 1945), are correlated directly with soil fertility and agricultural yields. The Prairie Farm is level fertile bottomland, and the hunter ordinarily takes about 15 cocks per hundred acres. At Rose Lake, which is rolling gravelly upland, the expected kill is 10 to 12.

On a basis of experience thus far we can conclude that at Rose Lake normally distributed hunting pressure of from 100 to 125 gun-hours per hundred acres will harvest the available crop of pheasants. Hunting above that intensity is largely unrewarded, and for convenience of usage we have designated these surplus hours as "excess" hunting. The usual distribution of hunting pressure is about 50 per cent the first week, 30 per cent the second week, and 20 per cent the last eight days. Two-thirds of the hunting is concentrated on the opening day and week ends. Distribution of the kill is approximately 70 per cent the first week, 20 per cent the second week, and 10 per cent the last eight days. Table 6 gives hunting pressure distribution for individual years at Rose Lake, and Table 7 shows the kill percentages by week. Some details of the 1940 game harvest are given in Fig. 2. Late in the season there were fewer cocks left to be shot and they were actually more difficult to bag, as evidenced by diminished success in proportion to the number of birds flushed. Cocks and hens both flushed a little more readily, and thus at a greater distance from the gun, late in the season.

TABLE 6.—HUNTING PRESSURE AT ROSE LAKE.
Per cent by week of season

	1940	1941	1942	1943	1944	1945
1st week	*50*	*53*	*61*	*48*	*50*	*66*
2nd week	*28*	*31*	*25*	*30*	*24*	*21*
3rd week*	*22*	*16*	*14*	*22*	*26*	*13*

* Last eight days.

One of the measures commonly considered in the case of a decline in pheasants is to shorten the season. Since only about 20 per cent of the hunting is done in the last eight days of the Michigan season, and 10 per cent of the kill occurs during that period, it is apparent that little would be accomplished by cutting, for example, a week from the open season.

EFFECTS OF SHOOTING

A study of Tables 6 and 7 illustrates the consistency of hunting trends in

TABLE 7.—PHEASANT KILL BY WEEK OF SEASON AT ROSE LAKE.

	Cocks killed	Per cent 1st week	Per cent 2nd week	Per cent 3rd week
1940	158	*72*	*19*	*9*
1941	245	*73*	*20*	*7*
1942	207	*75*	*19*	*6*
1943	123	*67*	*26*	*7*
1944	128	*64*	*15*	*21*
1945	52	*88*	*12*	*0*

years when figures were largest and hence of greatest significance. The best pheasant harvest for both Rose Lake and the Prairie Farm was in 1941, and this kill followed two years when hunting pressure was far above that sustained by the average farm (Figure 1). The high population of 1941 in itself is conclusive evidence that no overshooting occurred. Figures for Rose Lake (Table 1) indicate that each year at least 24 per cent of the cocks escaped the fall shooting, which left a 1:4 or better sex ratio for breeding.

Pheasant numbers and the kill were much the same at Rose Lake in 1939 and 1940 (Figure 1) even though in 1940 hunting pressure was three-fourths again as heavy. In those two years 100 hours of hunting per hundred acres

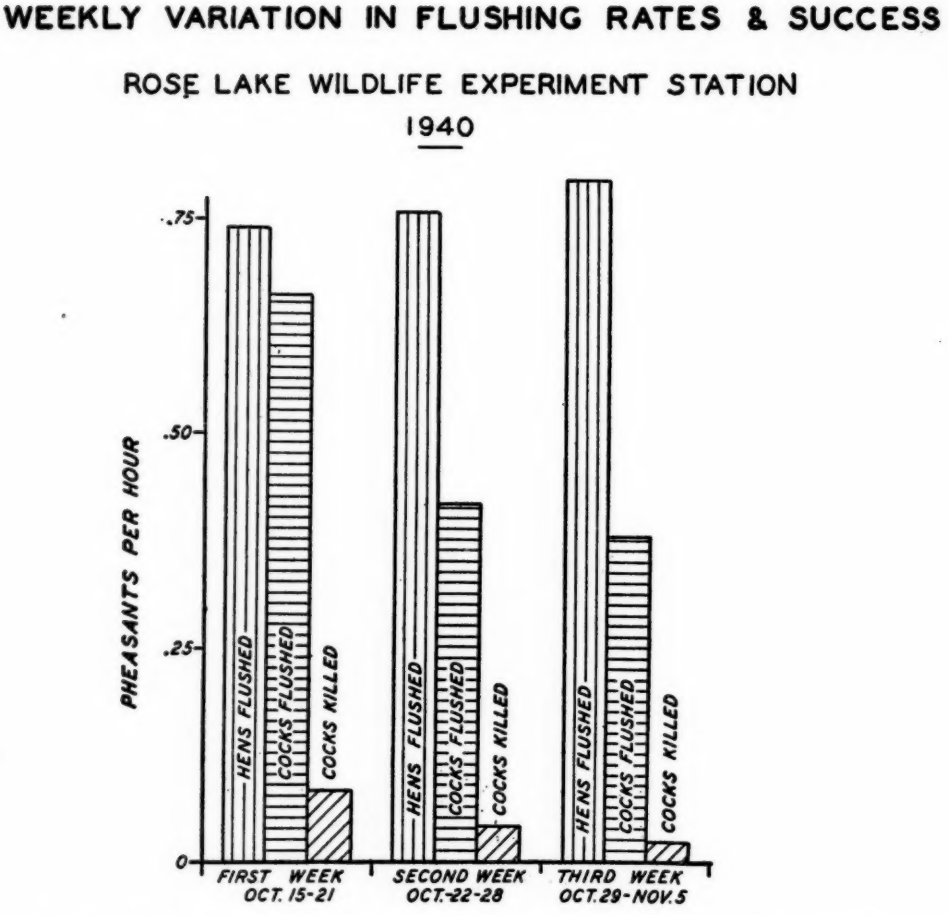

FIG. 2.—The flushing rate for hens increased slightly through the season. As cocks were removed from the population, the flushing rate dropped off. The rate of kill, however, declined still more rapidly, indicating that cocks flushed more readily and farther from the hunter as the season progressed.

probably was about sufficient to harvest the total available crop of pheasants. The additional 77 hours the second season did not by any means wipe out the cock birds. In fact it had no unfavorable effect that could be determined. But hunter success dropped 37 per cent in 1940 when nearly twice as much time was required to kill the average bird. This illustrates the unreliability of hunter success as an index of pheasant numbers when figures are based upon a limited heavily-hunted area. Under these conditions hunter success is dependent as much upon the number of hunters as upon the density of game. In a year like 1939 or 1940 the maximum amount of *productive* hunting which the Rose Lake area will furnish is about 100 to 125 hours per hundred acres. However, there need be no limitation to hunting pressure as far as the danger of over-shooting is concerned. The only result of excessive hunting has been that many hunters go home empty handed and, possibly, with the impression that pheasants are scarce.

Both of the study areas under discussion have been attractive to hunters every year because of the convenience of the system. In spite of this, a comparison of one fall season with another shows the tendency of hunting pressure to adjust itself to the number of birds available. In 1941 the high population of pheasants at Rose Lake and the Prairie Farm resulted in exceptionally good shooting. As a result, hunters returned frequently and gun pressure mounted to a point far above the level productive of game in the bag. Thus abundance was in itself the incentive which guaranteed a complete harvest.

The close interdependency between hunting and kill are reflected in a comparison of the removal rates for 1940 through 1942 (Table 7). The removal rate for 1941 was practically the same as the other years in spite of the differences in absolute numbers of pheasants and hours of hunting. The trend held into 1943, but after 1942 the figures are less significant statistically and a greater variability is evident. Shick (1942) found that over a period of six years 73 per cent of 7,388 pheasants shot at the Prairie Farm were taken the first week.

This self-regulatory nature of gun pressure is further illustrated by a compilation of Michigan kill records by Gower (1942), which showed that hunters are attracted to various portions of the state in proportion to the density of pheasants. Although the total pheasant kill varies greatly from one county to another, the kill per hunter is surprisingly constant. Obviously, for the state as a whole, the extent to which hunting is rewarded is what distributes gun pressure and the resulting kill. Gunners do not work restricted areas until they are completely shot out but shift about looking for the good shooting. Hunting of the intensity found at Rose Lake is very exceptional, since factors other than a high kill help to attract hunters.

CONCLUSIONS

From these records it appears that a given area can be conceived as having a carrying capacity for cock pheasants in the face of heavy hunting. At first the kill curve goes up steeply as the most available birds, primarily young of the year, are harvested. However, the principle of diminishing returns asserts itself, and the yield of cocks levels off to

a point where almost none is available to the hunter. Cover conditions, water levels, weather, and the number of hens present no doubt help to determine the point at which hunting becomes ineffective and make that point fluctuate somewhat from year to year. At Rose Lake in a season when about 10 birds per hundred acres are bagged by hunters, we expect at least 25 per cent of the pre-hunting cock population to be alive when the shooting is over. It is possible that these estimates can be made more precise when 10 or 15 years of data can be evaluated, but there is no reason for doubting the general significance of information now at hand. In territory with adequate cover, proper basic regulations, and effective law enforcement, there is little danger of over-shooting the ringneck pheasant.

In application these data lead to the conclusion that such management measures as refuges to protect pheasants from shooting, the restocking of cocks for breeding, and the season bag limit are not necessary in Michigan. If there was widespread shooting of hens where pheasants are scarce or large areas denuded of suitable escape cover the situation might well be different. Thus far there are no indications of significantly large areas of pheasant range in this state where the principles established at Rose Lake and the Prairie Farm do not apply.

SUMMARY

Hunting records have been analyzed for two areas of Michigan farmland totalling nearly 10,000 acres. Seven years of hunting at the Rose Lake Wildlife Experiment Station in Clinton County and nine years at the Prairie Farm in Saginaw County indicate that, within wide limits, there is little danger of overshooting the ringnecked pheasant. Both areas have good escape cover. The hunting season is 22 days, extending from October 15 to November 5. The daily bag limit is two cocks.

Hunting pressures on the study areas have varied from 99 to 256 gun-hours per hundred acres. A Survey in 1940 showed that most private farms are hunted from 40 to 60 gun-hours per hundred acres. On the study areas the pheasant crop has depended upon the breeding season production as governed by spring weather more than any other factor. Shooting has not depleted the male birds nor has it had any discernible adverse effect. At Rose Lake in an average year at least 25 per cent of the cocks can be expected to escape even the heaviest hunting. Hunting trends have been consistent for most years. Approximately 50 per cent of the hunting is done the first week, 30 per cent the second, and 20 per cent the last eight days. About 70 per cent of the pheasant kill can be expected the first week, 20 per cent the second and 10 per cent the last eight days. Thus shortening the season by as much as a third would be expected to preserve only about 10 per cent of the present season kill.

At Rose Lake the first 100 to 125 gun-hours (per hundred acres) harvests the bulk of the pheasant crop, and hunting beyond that point is largely unrewarded. Large bird populations attract heavy hunting pressure and insure the harvesting of more cocks when the population is high. Low pheasant numbers mean discouraged hunters and lower gun pressure. In this state there is

no need for refuges to preserve cocks from shooting or for the restocking of cocks as breeders.

LITERATURE CITED

ALLEN, DURWARD L. 1938. Ecological studies on the vertebrate fauna of a 500-acre farm in Kalamazoo County, Michigan., Ecol. Mon., **8**: 347–436.

1940. Rose Lake Wildlife Experiment Station. Michigan Conservation, **9**(9)6–7, 10.

1942a. That season limit. Michigan Conservation, **11**(2)4–5.

1942b. A pheasant inventory method based upon kill records and sex ratios. Trans. N. Amer. Wildl. Conf., **7**: 329–333.

1943. Michigan fox squirrel management. Michigan Dept. Conservation, Game Div., Publ., **100**: 1–404.

1946. What happened to the pheasant? Michigan Conservation, **15**(2)3–4.

BENNETT, LOGAN J. 1945. The pheasant in Pennsylvania and New Jersey. In McAtee, W. L. The ring-necked pheasant. Amer. Wildl. Institute., 11–31.

BURROUGHS, R. D. and LAURENCE DAYTON. 1941. Hunting records for the Prairie Farm, Saginaw County, Michigan, 1937–1939. Jour. Wildl. Mgt., **5**: 159–167.

BUSS, IRVEN O. 1946. Wisconsin pheasant populations. Wisconsin Conservation Dept. Publ., **326**: 1–184.

CARLSON, C. EDWARD. 1946. Status of pheasants, 1946. Conservation Volunteer, **9**(54) 30–33.

DAY, ALBERT M. 1946. The problem of increased hunting pressure on waterfowl. Trans. N. Amer. Wildl. Conf., **11**: 55–61.

ERRINGTON, PAUL L. and F. N. HAMERSTROM, JR. 1937. The evaluation of nesting losses and juvenile mortality of the ring-necked pheasant. Jour. Wildl. Mgt., **1**: 3–20.

GOWER, W. CARL. 1942. Pheasants and pheasant hunters go together. Michigan Conservation, **11**(8)9.

HAMERSTROM, F. N. JR. 1936. A study of the ring-necked pheasant in north-west Iowa. Iowa State College Jour. Sci., **10**: 173–203.

LEEDY, DANIEL L. 1939. Some land-use factors related to pheasant production. Trans. N. Amer. Wildl. Conf., **4**: 525–533.

LEOPOLD, ALDO, THEODORE M. SPERRY, WILLIAM S. FEENEY, and JOHN A. CATENHUSEN. 1943. Population turnover on a Wisconsin pheasant refuge. Jour. Wildl. Mgt., **7**: 383–394.

LINDUSKA, JOSEPH P. 1943. A gross study of the bursa of Fabricius and cock spurs as age indicators in the ring-necked pheasant. Auk, **60**: 426–437.

PERRY, ROBERT F. 1946. An appraisal of pheasant abundance in New York State during 1945 and some of the factors responsible for the recent decline. Trans. N. Amer. Wildl. Conf., **11**: 141–152.

SHICK, CHARLES. 1942. Habitat requirements of the ring-necked pheasant. Michigan Dept. Conservation, Game Div., Pittman-Robertson Proj. 7-r, Final Rept. (unpub.).

TUBBS, FARLEY F. 1946. Pen-reared birds don't help sport. Michigan Conservation, **15**(3) 10–11.

SIZE OF BURSA OF FABRICIUS COMPARED WITH OSSIFICATION OF SKULL AND MATURITY OF GONADS[1]

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Introduction

The bursa of Fabricius, a dorsal diverticulum of the lower intestine, is usually present in young birds and absent in adults. Recently this structure has attracted attention as a means of determining the age of individuals. The conventional criteria for establishing the age of birds are the degree of ossification of the skull, the condition of the gonads, and the plumage, but the simultaneous use of several structures should permit a more accurate determination of the age of an individual bird. It is the aim of this paper to compare the maturity of the bursa of Fabricius with the maturity of the skull and of the gonads. Plumage, a fourth character useful in determining age, is not considered here.

The accurate determination of the age of individual birds is of considerable importance in game management, as has been explained by Leopold (1933), Gower (1939), and Petrides (1942); and several investigations have been organized to determine exactly the size of the bursa of game birds (Hochbaum, 1942; Linduska, 1943; Kirkpatrick, 1944). The age of wild birds now is assuming importance in relation to human diseases which are primarily avian or mammalian, because the interpretation of tests for antibodies in wild birds requires a knowledge of the age of the individual bird. The presence of antibodies in young birds means that the etiologic agent is temporally near, while their presence in adults and absence in young birds means that the agent is no longer present. Enzootiologic investigations of this type are in their infancy.

The bursa of Fabricius is a lymphoepithelial organ, presumably the site of production of blood elements, and lies dorsally above the cloaca. At least in some species it has an opening exteriorly, reaches it maximum size when the bird is 4–6 months old, and then begins involution. Linduska (1943) and Kirkpatrick (1944) have developed methods of measuring the size of the bursa in live pheasants by insertion of a thin glass rod.

Obviously the investigation of the relation of the size of the bursa of Fabricius to the age of the bird can best be made with birds of known ages, as has been done for some species (Riddle, 1928; Kirkpatrick, 1944). However, because of the time and expense of raising and studying the birds, such detailed investigations can be accomplished only

[1] The investigations on which this article is based were made with the support and under the auspices of the Yellow Fever Research Service maintained jointly by the Ministry of Education and Health of Brazil and the International Health Division of The Rockefeller Foundation.

for certain economically valuable species. Nevertheless, there are many species which are of minor importance and there are others, such as flycatchers and woodpeckers, which are most difficult to raise in sufficient numbers. These species may merit study of the bursa in wild individuals as an aid to determination of age.

The observations reported in this paper were obtained in a study of the hosts and vectors of jungle yellow fever. Birds have been suspected of being involved in the movements of the disease throughout southern Brazil, and hence studies were made of the birds and of the ecology of the forests (Davis, 1945). For a large series of birds the conventional data were recorded and, in addition, the size of the bursa was noted as large or small. The sacrum was cut out and preserved in Bouin's fluid, and the gonads were subsequently sectioned and characterized as immature, inactive, progressing, active, or regressing. The degree of ossification of the skull was noted at the time of making a study specimen. The maturity of the plumage was not recorded because plumage sequences are poorly known in these species. The skins are deposited in the Museu Nacional at Rio de Janeiro. The collections have been used to describe the breeding season of the birds of the region (Davis, 1945).

The correlation of the size of the bursa, the maturity of the gonads, and the ossification of the skull may make possible a more accurate determination of the age of individuals. Although the exact age in months may not be known without studies on captive or marked birds, nevertheless individuals of the same species can be compared among themselves, which is often adequate for game management or enzootiologic studies where it is usually sufficient to know that one bird is older than another. It is fully realized that great care and caution must be exercised in drawing conclusions as to the relative age of individuals, but it is felt that information of value can be obtained by this method.

CORRELATION OF BURSA WITH SKULL AND GONADS

Data concerning the size of the bursa, the ossification of the skull, and the maturity of the gonads are the basis of this report. These characters are clearly qualitative, and a difference of opinion can exist concerning certain individuals; also some errors may occur. Nevertheless, it is felt that in general the data are accurate and present a true picture of the situation for the more common birds. Species represented by less than 3 specimens are not considered.

The developmental status of bursa, skull, and gonads for individuals of 20 common species are presented in Table 1, classified according to the various combinations of maturities and grouped by seasons. The seasons are fully described by Davis (1945) but may be summarized here as follows: hibernal or winter (June-July); prevernal or early spring (August-September); vernal or spring (October-November); aestival or summer (December-January); serotinal or late summer (February-March); autumnal (April-May).

The specimens are easily divided into classes according to the relative order of attainment of maturity of the bursa, skull, and gonads:

1. Birds with a large bursa, unossified skull, and immature gonads are clearly very young individuals. This group is the second largest.

2. Birds with a small bursa, unossified skull, and immature gonads are clearly young birds but older than class 1. In these individuals the bursa has regressed rapidly. This is the fourth largest class. Birds of classes 1 and 2 are presumed to have been hatched in the present or immediately preceding breeding season.

3. Birds with large bursa and unossified skull but mature gonads are presumed to be individuals of a late hatch of the preceding breeding season, which have come under the influence of gonadal stimulation before the skull has had sufficient time to mature. Such individuals comprise a small part of the collection.

4. Birds having a small bursa, unossified skull, and mature gonads probably come from a late hatch and are older than birds of class 2. This is the third largest class.

5. Birds with large bursa, ossified skulls, and immature gonads are from early broods; the gonads are not stimulated before the skull matures. This is a very small group.

6. Birds with small bursa, ossified skull, and immature gonads are from an early brood of the previous season; the gonads did not begin sexual development until after the skull had matured. This is a fairly large class.

7. Birds with small bursa, ossified skull, and mature gonads are obviously adult individuals and comprise the largest class.

8. The class including birds having a large bursa but ossified skull and mature gonads is represented by only one individual and probably indicates an error in the characterization of the size of the bursa.

As an example of the manner of interpretation of Table 1 let us consider the species *Hemitriccus diops*, of which 15 individuals were collected. The 4 individuals of class 1 are obviously young and were probably hatched at about the serotinal season. The 1 individual of class 2 was hatched perhaps in the prevernal season. The 3 individuals of class 4 are perhaps the same age in months as the bird in class 2, but it is presumed that they were hatched in a late brood and hence the gonads were stimulated before the skull had time to mature. The 1 individual in class 6 is more mature, but the gonads have not yet been stimulated. The 6 members of class 7 are obviously adults. Thus, in order of age the specimens in any season may be ranked with class 1 obviously the youngest, classes 2 and 4 about the same age, class 6 a little older, and class 7 clearly the oldest.

The grouping according to seasons for the commoner species in Table 1, shows that most individuals may be classed with certainty in relation to other individuals collected. It should be noted that birds of class 4 were nearly all collected in the first part of the breeding season (September-November). There are, however, a few individuals of class 6 which were collected in the first few months of the breeding season. The flycatcher *Phylloscartes oustaleti* is noteworthy because the skull seems to mature so slowly: perhaps 2 years are required.

The maturity of bursa, skull, and gonads in all species collected in the region is shown according to seasons in Table 2. Percentages are used because the number of specimens varied from season to season. It will be noted that the percentage of adults is highest in the early part of the breeding season and that the percentage of young (classes 1 and 2) is highest in the serotinal season, as would be expected. Class 4 is most common in the early part of the breeding season, as would be expected if

TABLE 1.—MATURITY OF BURSA, SKULL AND GONADS FOR 20 COMMON SPECIES OF BIRDS, ACCORDING TO SEASONS.

Species	Class	Hibernal	Prevernal	Vernal	Aestival	Serotinal	Autumnal	Total
DENDROCOLAPTIDAE:	1					1	2	3
	2							
Dendrocolaptes platyrostris	3							
	4							
	5							
	6						1	1
	7	1		2		1	1	5
	1	1						1
	2							
Xiphocolaptes albicollis	3							
	4		1					1
	5							
	6							
	7	4	1	3	1			9
	1							
	2							
Lepidocolaptes fuscus	3							
	4							
	5							
	6		1					1
	7	2	3	1	2		2	10
	1							
	2							
Sittasomus griseicapillus	3							
	4							
	5	1						1
	6		2					2
	7	1	1		1	1	1	5
FURNARIIDAE:	1		1				1	2
	2						1	1
Anabazenops fuscus	3							
	4		1					1
	5							
	6							
	7	4	3	2	1		2	12
	1		1		1	2	2	6
	2				1	1		2
Syndactyla rufosuperciliata	3							
	4		2	1				3
	5							
	6				1			1
	7		1		2			3
	1						1	1
	2					1	1	2
Xenicopsoides amaurotis	3							
	4			4	1	1		6
	5							
	6		1					1
	7	2	4	3	1	1	4	15
	1					1	1	2
	2							

TABLE 1.—(Continued)

Species	Class	Hibernal	Prevernal	Vernal	Aestival	Serotinal	Autumnal	Total
Philydor rufus	3							
	4							
	5							
	6		1					1
	7	2	3	1	1	2	1	10
FORMICARIIDAE:	1				1	1		2
	2							
Thamnophilus caerulescens	3							
	4							
	5							
	6							
	7	2	5				3	10
	1				1		1	2
	2							
Dysithamnus mentalis	3							
	4		1	1				2
	5							
	6							
	7	2	3		1		2	8
	1					1	1	2
	2							
Myrmeciza loicata	3							
	4				1			1
	5							
	6						1	1
	7	2	1	1	1		1	6
	1					1	1	2
	2							
Chamaeza ruficauda	3							
	4							
	5							
	6							
	7	1	2	2			2	7
PIPRIDAE:	1	1						1
	2							
Chiroxiphia caudata	3							
	4		1					1
	5							
	6							
	7	1	2				4	7
	1						1	1
	2	1						1
Ilicura militaris	3	1						1
	4		1					1
	5							
	6							
	7	5	1					6
TYRANNIDAE:	1					1		1
	2							
Empidonax euleri	3							
	4							
	5							
	6							
	7		7	2	1	1		11

TABLE 1.—(Continued)

Species	Class	Hibernal	Prevernal	Vernal	Aestival	Serotinal	Autumnal	Total
	1							
	2							
Tolmomyias	3							
sulphurescens	4	1					1	2
	5							
	6	1						1
	7	3	1	1			1	6
	1	4						4
	2					1		1
Hemitriccus	3							
diops	4		2	1				3
	5							
	6	1						1
	7	3	1		2			6
	1	1					3	4
	2	1				1	1	3
Phylloscartes	3							
oustaleti	4		2		1			3
	5							
	6							
	7	1						1
TURDIDAE:	1					1	1	2
	2					1	1	2
Platycichla	3					1		1
flavipes	4							
	5							
	6							
	7	3	2	2	3	1		11
THRAUPIDAE:	1						1	1
	2							
Thraupis	3					1		1
ornata	4							
	5							
	6							
	7	2	1		3	1	4	11

these individuals are birds whose gonads have been stimulated before the skull has had time to mature. Class 3 should show the same relationships as class 4, but the percentages are very irregular. Birds of class 6 occurred in various seasons and may represent individuals which do not become sexually mature till the second year. Birds of class 5 appear to be individuals whose skulls matured very rapidly.

DISCUSSION

A comparison of the maturity of the bursa, skull, and gonads in a series of birds collected in the field is of value in determining the ages within such groups. For game management or enzootiologic investigations it is often sufficient to know relative ages of individuals, and the knowledge of the age in months is often unnecessary refinement. By methods described in this re-

TABLE 2.—MATURITY OF BURSA, SKULL, AND GONADS, ACCORDING TO MONTHS AND FOR ALL SPECIES.

Class	Remarks	Bursa	Skull	Gonads	Per cent of total individuals collected each season						Total specimens
					Hibernal	Prevernal	Vernal	Aestival	Serotinal	Autumnal	
1	Very young	lg.	un.	im.	*10*	*1*		*10*	*33*	*27*	92
2	Young: bursa regresses rapidly	sm.	un.	im.	*2*	*2*		*3*	*14*	*5*	26
3	Late brood: gonads stimulated before skull matures	lg.	un.	ad.	*4*	*2*			*5*	*1*	16
4	Late brood: bursa regresses rapidly	sm.	un.	ad.	*1*	*11*	*8*	*4*	*1*	*3*	34
5	Early brood: gonads not stimulated before skull matures	lg.	oss.	im.	*4*	*1*		*1*		*1*	9
6	Early brood: bursa regresses rapidly	sm.	oss.	im.	*2*	*3*		*6*		*3*	17
7	Adults	sm.	oss.	ad.	*77*	*80*	*92*	*74*	*47*	*60*	520
	Total specimens				166	162	85	69	82	150	714

port, it should be possible to arrange a collection of 10 or 20 individuals of one species in order of age with little hesitancy. Care should be exercised in attempting to compare the ages of birds belonging to different species.

It has been assumed that the bursa involutes before the skull becomes ossified. While this appears to be the case for most species (note especially the *Furnariidae*), there exists the possibility that in some species the skull ossifies before the bursa becomes small. No species in the present study clearly fits this classification, but there are some scattered examples of the prior maturity of the skull. The gonads presumably mature in response to the suitable external stimuli of the environment and in some species control the involution of the bursa (Asmundson et al, 1937; Kirkpatrick and Andrews, 1944) and possibly the ossification of the skull. However, involution may occur before (*Sittasomus*, class 6) or after (*Ilicura*, class 3) the gonads are mature.

The data in this paper have been presented with some hesitancy because of their fragmentary nature for many species. However, it is felt that the method of determining ages of birds is of value and that additional data are required to determine the limitations of the method. It is urged that other investigators collect their data with this result in mind.

SUMMARY

The bursa of Fabricius may be used to determine the age of individuals because of its large size in young birds and small size in adults. A correlation of the size of the bursa with the maturity of the gonads and with the ossification of

TABLE 3.—FAMILIES AND NUMBER OF SPECIES USED TO FORM TABLE 2.

Family	Number of species
Tinamidae (Tinamous)	1
Accipitridae (Hawks)	1
Phasianidae (Pheasants)	1
Rallidae (Rails)	1
Columbidae (Pigeons)	1
Cuculidae (Cuckoos)	3
Psittacidae (Parrots)	2
Caprimulgidae (Goatsuckers)	1
Micropodidae (Swifts)	1
Trochilidae (Hummingbirds)	1
Trogonidae (Torgons)	2
Rhamphastidae (Toucans)	1
Picidae (Woodpeckers)	2
Dendrocolaptidae (Woodhewers)	7
Furnariidae (Ovenbirds)	13
Formicariidae (Antbirds)	13
Conopophagidae (Ant-pipits)	1
Cotingidae (Cotingas)	6
Pipridae (Manakins)	4
Tyrannidae (Flycatchers)	19
Oxyruncidae (Sharpbills)	1
Troglodytidae (Wrens)	1
Turdidae (Thrushes)	2
Vireonidae (Vireos)	1
Cyclarhidae (Pepper shrikes)	1
Coerebidae (Honey creepers)	1
Compsothlypidae (Wood warblers)	2
Ploceidae (Weaver finches)	1
Icteridae (Blackbirds)	2
Thraupidae (Tanagers)	11
Fringillidae (Sparrows)	6

the skull may permit a more accurate determination of the age of birds for use in game management and enzootiologic investigations. This report compares the size of the bursa, ossification of the skull, and the maturity of the gonads in a collection of about 700 Brazilian birds.

The specimens are divided into 7 classes according to the order of attainment of maturity of the bursa, skull, and gonads.

When the birds are grouped according to the season of collection, it is found that the percentage of adults (Class 7) is highest in the early part of the breeding season and that the highest percentage of young individuals (Classes 1 and 2) are found in the latter part of the breeding season.

This method offers the possibility of a more detailed determination of the age of wild birds which for economic or practical reasons cannot be raised in captivity for the purpose of establishing characters from birds of known ages.

LITERATURE CITED

ASMUNDSON, V. S., C. A. GUNNAND, and A. A. KLOSE. 1937. Some responses of the immature female fowl to injections of mare gonadotropic hormone and oestrin. Poul. Sci., **16**: 194–206.

DAVIS, DAVID E. 1945. The annual cycle of plants, mosquitoes, birds, and mammals in two Brazilian forests. Ecol. Monog., **15**: 243–295.

GOWER, W. C. 1939. The use of the bursa of Fabricius as an indicator of age in game birds. N. Amer. Wildl. Conf. Trans., **4**: 426–430.

HOCHBAUM, H. A. 1942. Sex and age determination of waterfowl by cloacal examination. Trans. N. Amer. Wildl. Conf., **7**: 299–307.

KIRKPATRICK, C. W. 1944. The bursa of Fabricius in ring-necked pheasants. Journ. Wildl. Manag., **8**(2): 118–129.

KIRKPATRICK, C. M., and F. N. ANDREWS. 1944. The influence of the sex hormones on the bursa of Fabricius and the pelvis of ring-necked pheasants. Endocrinology **34**: 340–345.

LEOPOLD, ALDO. 1933. Game management. New York. Charles Scribner's Sons.

LINDUSKA, J. P. 1943. A gross study of the bursa of Fabricius and cock spurs as age indicators in the ring-necked pheasant. Auk., **60**: 426–437.

PETRIDES, G. A. 1942. Age determination in gallinaceous game birds. N. Amer. Wildl. Conf. Trans., **7**: 308–328.

RIDDLE, OSCAR. 1928. Growth of the gonads and bursa of Fabricii in doves, with data for body growth and age at maturity. Amer. Journ. Physiol., **86**: 248–265.

THE FERRET AS AN AID TO WINTER RABBIT STUDIES[1]

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One of the most urgent needs of the game biologist is for simple, reliable methods of censusing or obtaining indices to the number of animals on sample areas. Obtaining other types of information necessary to proper management requires the actual handling of live individuals, and procedures which facilitate accumulation of such biological data are likewise in demand. At the Rose Lake Wildlife Experiment Station in Clinton County, the Game Division of the Michigan Conservation Department has devoted considerable effort to the development of such study techniques in connection with a general research program on farm game.

In life history and management studies of the cottontail rabbit various techniques for estimating populations, (live-trapping, pellet counts, track counts, direct counts of started rabbit, hunting kill, etc.) have been tried by Trippensee (1934), Allen (1938), Haugen (1942), Hendrickson (1938, 1939), Ingles (1941), and others. Working in Ohio, Trautman, as quoted in Trippensee (1934), found the ferret an effective means of obtaining rabbits for breeding purposes and incidentally obtained various biological notes of value. Ferrets also have been commonly used as an aid in hunting and in control work directed against rabbits, but their use as a tool in research studies does not appear to have been given trial. During the winters of 1941–42 and 1942–43 the possible value of ferrets as an aid in winter studies of Mearns' cottontail (*Sylvilagus floridanus mearnsii* Allen) was investigated. The procedure followed and a general statement of results provided the basis for this report. A more detailed treatment of ecological phases of the work will be presented in a separate paper.

Methods

The ferrets used in these studies were several of a group confiscated by the law enforcement branch of the Conservation Department, and were being held mainly for use in control of rabbits in orchard areas. The three individuals proved to be very docile and showed no inclination to bite or scratch when handled. However, Mr. L. A. Davenport, who has had experience using ferrets in control work, informs me that occasional vicious individuals need care in handling.

In our work, known burrow areas were visited and the ferret was introduced into den entrances which showed signs of use by rabbits. A burlap sack or bag made of heavy net was held in place over the den entrance and any nearby openings were similarly covered. The fact that many dens had two or more openings made it advisable for at least two men to participate in the work.

[1] The information given here was obtained as part of the program of Federal Aid in Wildlife Restoration Project 2-R, Michigan Conservation Department. D. L. Allen, then Biologist in Charge of the Rose Lake Station, gave many helpful suggestions during the course of the study, and Frank Martin and Clare File assisted in the field work.

Rabbits generally dashed from the dens at top speed and it was necessary to hold the bag opening securely in place to prevent escape. Not infrequently a den opening, closed with snow and not known to be present, was revealed as a startled rabbit darted to the surface through the snow covering. Following capture, the animals were examined, marked with numbered fingerling ear-tags, and released at the point of capture.

Some use was also made of ferrets in capturing rabbits under the cover of small buildings, brush-piles, etc. In these situations the shelter was first surrounded with a 4-foot, 2-inch mesh net and rabbits were caught with hand nets as they sought to escape through the enclosure. It was found, however, that a heavy fall of soft snow greatly impeded the movement of rabbits, and under these conditions such surface cover could be explored with a ferret and the rabbits caught easily by hand as they struggled in the deep snow.

A disturbing factor in the initial work was occasioned by the ability of the ferrets to make frequent kills in burrows. Aside from the loss of rabbits, the failure of the ferret to emerge from dens following a successful capture meant the loss of its services for the day. Under such circumstances a box-trap containing nesting materials and left at the den opening invariably held the ferret on the following morning. On a few occasions following such kills, cloth bags or other protective materials were left near the burrow, and these proved sufficient to encourage the animal to remain near the den until its handlers returned. Attempts to reduce their killing propensities by use of a muzzle, fetters of various types, and collar and leash proved impracticable. However, close clipping of the front toe-nails, and shortening of the canine teeth, was later found to reduce their efficiency as killers without handicapping them for the work at hand.

General Success

During the first winter of study (January, 1942) work with ferrets was conducted during 19 days for a total of about 100 man-hours. In this time 95 rabbits were started, of which 51 individuals were captured. A concurrent program of trapping to check the relative efficiency of the two methods was not attempted, but with a similar winter population in 1941, 62 individuals were taken in 3 weeks of intensive trapping for 4,025 trap-nights. From the standpoint of the labor involved in censusing limited areas and obtaining individuals for examination, the use of ferrets proved considerably more economical of time and effort than live-trapping. Also, it was found to be most effective under conditions which complicate attempts to live-trap a population. In our studies of the cottontail, winter live-trapping has been irregular and uncertain because of the frequent fouling of traps due to freezing, drifting of snow, etc. Ferret work under such conditions was found to be a practical procedure for getting mid-winter information.

Of the various factors which might influence den use by rabbits, air temperature in itself appeared to be highly important. Although these studies showed that rabbits made some use of dens at temperatures above freezing, the most productive work with ferrets

was done on the coldest days. Under a range of temperatures of +32° to +12°F. a total of 64 ground dens was explored with a ferret and nine (14 per cent) were found to be occupied. With temperatures from +12° to −8°F. burrow occupancy by rabbits was three times as great, since 49 of 117 burrows (42 per cent) contained rabbits. Considering all attempts to start rabbits from the several types of cover worked (dens, brush piles, building foundations, etc), days with minimum readings of +12° to −8°F. proved nearly twice as successful as did days falling in the +32° to +12°F. temperature range. Under the first conditions mentioned, 139 situations were "ferreted" and 95 rabbits were started, whereas only 43 individuals were found in 112 attempts at temperatures of +32° to +12°F.

FATE OF RABBITS CAPTURED

Cottontails are essentially an annual crop and comparatively few individuals taken in live-trapping survive a full year to reappear in subsequent trapping. Following fall-winter hunting at Rose Lake, slightly over 50 per cent of the animals marked in January and February live-trapping were accounted for through later trapping or in the next hunting season. Among individuals taken with a ferret, the returns from 72 animals caught in January and February was appreciably lower—21 per cent. While it was apparent during the work that rabbits started from dens or other cover by ferrets were thoroughly terrorized, the decrease in returns from animals so caught compared with those taken in previous years by trapping does not necessarily indicate that they abandoned the area as a result of such an experience. Ferret work was undertaken partly in connection with a forced curtailment in station activities, and the smaller number of returns from rabbits taken in ferret work was probably at least partially due to the marked cut-back in live-trapping and other field activities during the war. However, the fact that no rabbit driven from a den was ever retaken in subsequent ferret work may indicate that an encounter with a ferret tends to discourage the rabbit from again entering a burrow.

With the exception of two individuals started from brush piles and recaught from the same piles with a ferret, all of 15 animals later accounted for appeared in live-trapping or in the hunting season kill. The following sample records show, however, that some individuals continued in residence at or near the site from which they were "ferreted." Rabbit #14829 (male) taken with the use of a ferret on January 12, 1942, was later trapped 11 times at the same locality; rabbit #14494 (female) was trapped four times from September 18, 1941 to February 3, 1942, when "ferreted," and was retaken three times by live-trapping in the same locality; rabbit #14839 (male) was "ferreted" January 13, 1942, retaken three times in trapping to September, 1942, and was shot by a hunter in the same woodlot on October 16, 1942; and rabbit #9842 (male) trapped on March 28, 1941, and "ferreted" January 12 and February 13, 1942 from the same locality, was recaught in a nearby trap on April 8, 1942.

SUMMARY

1. A method involving the use of ferrets for censusing cottontails on local areas and for obtaining individuals for

mid-winter examination was given trial during two years and found to have merit.

2. The procedure was found to have special utility in areas and under various conditions which complicate live-trapping as a means of obtaining certain biological information.

3. The use of brush piles and burrows by cottontails was observed to be strongly influenced by air temperatures. Consequently, the most fruitful work with ferrets was on cold days.

4. The failure to retake "ferreted" rabbits from burrows suggested that the experience may have established some reluctance in rabbits towards the use of den cover.

LITERATURE CITED

ALLEN, D. L. 1938. Michigan cottontails in winter. Journ. Wildl. Man., **3**: 307–322.

HAUGEN, A. O. 1942. Life history studies of the cottontail rabbit in southwestern Michigan. Amer. Midl. Nat., **28**: 204–244.

HENDRICKSON, G. O. 1938. Winter food and cover of Mearns' cottontail. N. Amer. Wildl. Conf. Trans., **3**: 787–793.

1939. Inventory methods for Mearn's cottontail. N. Amer. Wildl. Conf. Trans. **4**: 209–215.

INGLES, LLOYD G. 1941. Natural history observations on the Audubon cottontail, Journ. Mam. **22**: 227–250.

TRIPPENSEE, R. E. 1934. The biology and management of the cottontail rabbit. Univ. Mich. School For. and Cons. Unpublished Thesis.

HELMINTH PARASITES OF RABBITS OF THE GENUS *SYLVILAGUS*[1]

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INTRODUCTION

Cottontail and marsh rabbits of the genus *Sylvilagus* are among the most abundant and widely distributed of the small game mammals in the United States. Their abundance and popularity as game species have made them readily available for parasitological study. Many workers have taken advantage of this fact, and surveys of cottontail parasites have been completed in at least 16 states.

The objects of this paper are to synthesize the findings of these widespread investigations, to review the literature, to present original information on Minnesota cottontails, and to present keys for the identification of the known helminth parasites. Such information, it is believed, will be of value to parasitologists as well as to mammalogists and game managers interested in the life histories of the various cottontail and marsh rabbits.

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REVIEW OF LITERATURE[2]

The first report of parasites in cottontails is that of Leidy (1886) who discovered the nematode (*Dirofilaria scapiceps*) in the leg joints. Stiles' (1896) taxonomic and bibliographic report of the adult tapeworms of rabbits is a milestone in the study of rabbit parasites, as is Hall's (1916b) report on the nematodes.

Price (1928) examined swamp rabbits in Texas and published a list of parasites recovered from this host. Le Dune (1933) prepared the first extensive report of parasites of cottontails of the Ohio region. His record of the nematode *Trichostrongylus retortaeformis* has not been substantiated by other investigators. Material that he sent to the Bureau of Animal Industry was identified as *T. calcaratus*. In a letter to the writer (August, 1945) G. Dikmans of U. S. Department of Agriculture stated that *T. retortaeformis* has not been found in the United States.

Ward (1934) recovered 7 species of helminths from cottontail and swamp rabbits collected in Oklahoma. Dikmans (1935, 1937a, 1937b) described new species of nematodes from cottontails. Honess (1935) worked on tapeworms of the Black Hills cottontail (*Sylvilagus nuttalli*). Another regional study of cottontail rabbits and their parasites was made by Harkema (1936) in North Carolina.

Arnold (1938) made a valuable contribution to the knowledge of Anoplocephaline cestodes of North American rabbits. Moore (1939) examined 50 cottontails from the vicinity of Auburn, Alabama, and reported on the parasites. Clancy *et al* (1940) made a similar study of cottontails in Connecticut as did Morgan and Waller (1940) of Iowa cottontails and Smith (1940) of cottontail and swamp rabbits in Oklahoma.

Arnold (1941) described a new rabbit nematode (*Stunkardionema halla*) and placed it in the subfamily Trichostrongylinae. Rozycki (1941) made an extensive study of nematodes of cottontail rabbits collected in Missouri and Pennsylvania. He concluded that *S. halla* is probably the same worm as *Longistriata novibariae*, a species described by Dikmans. After examination of slides of *S. halla*, the writer is inclined to agree with Rozycki.

Bell and Chalgren (1943) reported 13 species of helminths from cottontails collected in Pennsylvania and Missouri. Herman and Jankieurcz (1943) made a survey of the parasitic fauna of the western cottontail (*Sylvilagus auduboni*) collected in California. In New York State Cheatum (1943) examined 33 cottontails and recovered 7 species of helminths including the lungworm (*Protostrongylus boughtoni*). *P. sylvilagii* described from the Rocky Mountain cottontail by Scott (1943) was synonymized with *P. pulmonalis* by Goble and Dougherty (1943). Haugen (1943) reported briefly on internal parasites recovered from 21 Michigan animals. Llewellyn and Handley (1945) summarized their findings of parasites collected from Virginia cottontails.

[2] Only the more important literature of helminth parasites of cottontail and marsh rabbits is referred to here. All references to the subject, however, are listed in the numbered bibliography. The numerals following the parasite names refer to the numbered items in the bibliography. Thus any parasite and its rabbit host are immediately associated with the proper author and reference.

SOURCE OF MATERIAL AND PARASITES RECOVERED

A total of 97 cottontails (*Sylvilagus floridanus mearnsi*) collected from 1932 to 1945 in southern Minnesota were examined for this study. Sixty-three of these animals were entire; 32 were without skins; and two were represented by stomachs only. Fifteen species of helminths were recovered. Concurrent infections were the rule rather than the exception. Twelve animals had no helminths; 25 had one species each; 23 had two species each; 24 had three species each; nine had four species each; one had five species; and one had six species. The percentage of hosts infected by each species of parasite is based on the parts of the host that were available for study. The data are summarized in Table 1.

Life histories of the various parasites recovered from Minnesota cottontails are known for the following: *Taenia pisiformis*, *Multiceps* sp., (immature stages in carnivores); *Obeliscoides cuniculi* (direct, no intermediate host); and *Trichostrongylus calcaratus* (direct, larvae burrow through the skin). The life cycle of *Hasstilesia tricolor* is unknown but probably involves snails as intermediate hosts. The intermediate hosts of the species of *Cittotaenia* are probably free-living mites. This is definitely known for *C. ctenoides*, a species occurring chiefly in European hares. The cycles of the nematodes not already mentioned are probably direct with the exception of *Physaloptera* sp.

No particular pathological effects due to helminths were noted in the rabbits. The 30 animals whose leg joints were examined for *Dirofilaria scapiceps* were negative.

TABLE 1—HELMINTH PARASITES RECOVERED FROM 97 COTTONTAIL RABBITS. PERCENTAGES ARE BASED ON THE PARTS AVAILABLE FOR STUDY.

Name of Parasite	No. Infected	% Infected
Trematodes or flukes		
Hasstilesia tricolor	1	*1.0*
Cestodes or tapeworms		
Cittotaenia pectinata	4	*4.2*
Cittotaenia perplexa	32	*33.6*
Cittotaenia variabilis	27	*28.4*
Cittotaenia sp.	8	*8.4*
Multiceps sp.	4	*4.2*
Taenia pisiformis	26	*27.3*
Nematodes or roundworms		
Dermatoxys veligera	27	*28.4*
Nematodirus triangularis	2	*2.1*
Obeliscoides cuniculi	24	*24.7*
Passalurus ambiguus	2	*2.1*
Passalurus nonanulatus	17	*17.9*
Physaloptera sp.	1	*1.0*
Trichostrongylus affinis	5	*5.2*
Trichostrongylus calcaratus	3	*3.1*
Trichuris leporis	12	*12.6*

HELMINTHS REPORTED FROM RABBITS OF THE GENUS *Sylvilagus*

EASTERN COTTONTAIL (S. *floridanus* and related forms.)

Trematodes or flukes.

Fasciola hepatica Linne, 1758 (34, experimental, 58)[3]

Hasstilesia texensis Chandler, 1929 (8)

* *Hasstilesia tricolor* (Stiles and Hassall, 1894) Hall, 1916 (5, 9, 20, 24, 27, 28, 29, 31, 35, 39, 43, 44, 53, 55, 56)

Cestodes or tapeworms.

Cittotaenia ctenoides (Railliet, 1890) Stiles, 1896 (51, 52, 58)

* *Cittotaenia pictinata* (Goez, 1782) Stiles and Hassall, 1896. Var. *americana* Douthitt, 1915 (4, 27, 28, 42)

* *Cittotaenia perplexa* (Stiles, 1895) Stiles and Hassall, 1896 (2, 5, 19, 42, 54)

[3] Numbers in parenthesis refer to authors in the bibliography who reported the parasite from the host. The complete author and date citation are given only the first time the parasite name appears in the lists.

* Recorded from Minnesota Animals. See Table No. 1.

* *Cittotaenia variabilis* (Stiles, 1895) Stiles and Hassall, 1896 (2, 5, 10, 12, 40, 42, 43, 44, 54)
Cittotaenia sp. (9, 39, 53)
Multiceps serialis (Gervias, 1847) Stiles and Stevenson, 1905 (37, 42, 43, 44, 52)
* *Multiceps* sp.
Raillietina stilesiella Hughs, 1941 = *R. salmoni* (Stiles, 1895) (42, 43, 54)
* *Taenia pisiformis* (Bloch, 1780) Gmelin, 1790 (5, 7, 9, 10, 12, 26, 27, 28, 31, 33, 35, 37, 39, 42, 43, 44, 52, 53, 58, 59, 60)
Taenia sp. (55)

Nematodes or roundworms.

* *Dermatoxys veligera* (Rudolphi, 1819) Schneider, 1866. (5, 9, 35, 37, 39, 41, 43, 48, 53)
Dirofilaria scapiceps (Leidy, 1886) Railliet and Henry, 1911 (25, 38, 39)
Graphidium strigosum (Dujardin, 1845) Railliet and Henry, 1909 (58)
Capillaria hepatica (Bancroft, 1893) Travassos, 1915 (58)
Heterakis gallinae (Gmelin, 1790) Freeborn, 1923 (35, accidental)
Longistriata novibariae Dikmans, 1935 (5, 15, 43, 48)
Nematodirus arizonensis Dikmans, 1937 (5, 48)
* *Nematodirus leporis* Chandler, 1924 (5, 7, 35, 37 44, 48)
* *Nematodirus triagularis* Boughton, 1932 (37)
* *Obeliscoides cuniculi* (Graybill, 1923) Graybill, 1924 (5, 7, 9, 10, 12, 27, 35 37, 39, 43, 44, 48, 53, 58)
Passalurus ambiguus (Rudolphi, 1819) Dujardin, 1845 (5, 12, 25, 37, 43, 48)
* *Passalurus nonanulatus* Skinker, 1931 (41, 58)
* *Physaloptera* sp. (5, 48)
Protostrongylus boughtoni (Boughton, 1932) Goble and Dougherty, 1944 (9, 21)
* *Trichostrongylus affinis* Graybill, 1924 (5, 22, 27, 48)
* *Trichostrongylus calcaratus* Ransom, 1911 (5, 9, 25, 27, 37, 43, 44, 47, 48, 52, 53)
Trichostrongylus ransomi Dikmans, 1937 (17)
Trichostrongylus sp. (28)
* *Trichuris leporis* (Froelich, 1789) Hall 1916 (5, 25, 35, 37, 39, 43, 44, 48, 52)
Wellcomia evaluta (Linstow, 1899) Sambon, 1907 (14)

NEW ENGLAND COTTONTAIL (*S. transitionalis.*)

Cestodes or tapeworms.
Cittotaenia variabilis (10, 12, 46a)
Taenia pisiformis (10, 12, 46a)
Nematodes or roundworms.
Obeliscoides cuniculi (10, 12, 46a)
Passalurus ambiguus (10, 12, 46a)

ROCKY MOUNTAIN COTTONTAIL (*S. nuttalii* and related forms.)

Cestodes or tapeworms.
Cittotaenia pectinata (4, 32)
Cittotaenia perplexa (2, 23, 32, 42)
Cittotaenia variabilis (32)
Raillietina retractilis (Stiles, 1895) Meggitt, 1924 (32)
Taenia pisiformis (26, 42)
Nematodes or roundworms.
Dermatoxys veligera (25)
Nematodirus neomexicanus Dikmans, 1937 (16)
Protostrongylus pulmonalis [=*sylvilagii*] (v. Froelich, 1802) Goble and Dougherty, 1943 (49, 50)
Trichostrongylus colubriformis (Giles, 1892) Ransom, 1911 (17)

WESTERN COTTONTAIL (*S. auduboni* and related forms.)

Cestodes or tapeworms.
Cittotaenia variabilis (30)
Raillietina retractilis (30, 42)
Taenia pisiformis (30, 42, 54)
Nematodes or roundworms.
Dermatoxys veligera (25, 30)
Nematodirus leporis (30)
Obeliscoides cuniculi (30)
Passalurus ambiguus (30)

MARSH RABBIT (*S. palustris* and related forms.)

Trematodes or flukes.
Hasstilesia tricolor (45)
Cestodes or tapeworms.
Cittotaenia variabilis (2, 42, 54)
Cittotaenia sp. (6, 57)

Multiceps serialis (42)
Taenia pisiformis (26, 42, 57)
Taenia sp. (55)
Nematodes or roundworms.
Dermatoxys veligera (57)
Dirofilaria scapiceps (1)
Longistriata novibariae (15)
Obeliscoides cuniculi (6, 57)

SWAMP RABBIT (*S. aquaticus* and related forms.)

Trematodes or flukes.
Hasstilesia tricolor (46)
Cestodes or tapeworms.
Cittotaenia ctenoides (52, 58)
Cittotaenia variabilis (46)
Multiceps serialis (46)
Raillietina stilesiella (46)
Nematodes or roundworms.
Graphidium strigosum (58)
Nematodirus leporis (46, 58)
Obeliscoides cuniculi (46, 52, 58)
Passalurus ambiguus (52)
Trichostrongylus calcaratus (46, 52)
Trichuris leporis (52, 58)

KEYS TO THE HELMINTHS OF COTTONTAIL AND MARSH RABBITS

TREMATODA

1. In the liver or bile ducts..... .....*Fasciola hepatica*
2. In the intestine.....(3)
3. Oral sucker 69 to 74μ long by 87 to 93μ wide; uterine coils loosely arranged.... .....*Hasstilesia tricolor*
   Oral sucker 86 to 115μ long by 120 to 128μ wide; uterine coils compactly arranged (solid massing of eggs)..... .....*Hasstilesia texensis*

CESTODA

1. Larva encysted in muscles or internal organs, or free in body cavity.....(2)
   Adults in intestine.....(3)
2. Larva a fluid-filled vesicle (coenurus) containing many heads. In the muscles .....*Multiceps spp.*
   (Larvae of *M. serialis* and *M. packii* not distinguishable.)
   Larva a bladder worm (Cysticercus) with little fluid and only one head. In internal organs or free in body cavity..... .....*Taenia pisiformis*
3. Rostellum with two circles of small hammer-shaped hooks. One set of reproductive organs in each segment..(4)
   Rostellum without hooks. Two sets of reproductive organs in each segment.(5)
4. Genital pores unilateral; one egg in each egg capsule. Hooks 40 to 120 in number 12μ long.....*Raillietina retractilis*
   Genital pores generally alternate; 3 to 15 eggs in each egg capsule. Hooks 120 in number 20μ long...*Raillietina stilesiella*
5. Cirrus pouch extending mediad of longitudinal excretory canal.....(6)
   Cirrus pouch lying laterad of longitudinal excretory canal.....(7)
6. Cirrus pouch just barely crossing longitudinal excretory canal and with a maximal length of 0.64 mm.; maximal body length, 100 mm.....*Cittotaenia perplexa*
   Cirrus pouch extending mediad of excretory canal, and with a maximal length of 1.8 mm.; maximal body length, 220 mm.....*Cittotaenia pectinata americana*
7. Maximal number of segments, 750; first appearance of female genital ducts between 45–50 segments; first indication of male genital primordia and ducts between 75–100 and 76–105 segments, respectively.....*Cittotaenia ctenoides*
   Maximal number of segments, 750; first appearance of female ducts between the 95–105 segments; male genital primordia and ducts originating at 125 and 175 segments, respectively.*Cittotaenia variabilis*

NEMATODA

1. Esophagus a fine tube imbedded in a column of glandular cells. Eggs with opercular plugs.....(2)
   Esophagus not imbedded in a column of glandular cells. Eggs without opercular plugs.....(3)
2. Anterior part of body longer than posterior, which is much thicker. In the intestine.....*Trichuris leporis*
   Anterior part of body shorter than posterior, which is only slightly thicker. In the liver.....*Capillaria hepatica*
3. Bursa, if present, with rays.....(4)
   Bursa, if present, without rays.....(17)
4. Bursa not conspicuous; parasites of respiratory tract.....(5)
   Bursa conspicuous; parasites of gastro-

intestinal tract.....(6)

5. Spicules of male 156–180μ long. Vagina of female 597–1116μ long. Provagina not prominent...*Protostrongylus pulmonalis*
Spicules of male 260–320μ long. Vagina of female 1900–2400μ long. Provagina prominent.....*Protostrongylus boughtoni*
6. Genetalia of the female double.....(7)
Genetalia of the female single.....(16)
7. Spicules short (less than 0.55 mm. long) and stout with crests and protuberances .....(8)
Spicules long and filiform 0.65 to 1.7 mm. .....(12)
8. Ventro-ventral and latero-ventral rays approximating at their tips; spicules cleft distally ending in two barbed processes; gubernaculum absent.....*Obeliscoides cuniculi*
Ventro-ventral and latero-ventral rays not approximating at tips; spicules not cleft distally; gubernaculum present.(9)
9. Spicules more than 175μ long, asymmetrical; distal end of right spicule smooth, of left spicule serrated.....*Trichostrongylus calcaratus*
Spicules less than 175μ.....(10)
10. Spicules 130 to 155μ, distal ends with two blunt recurved hooks; anus to tip of tail of female 140 to 165μ.....*Trichostrongylus affinis*
Distal ends of spicules without blunt, recurved hooks; anus to tip of tail of female less than 140μ.....(11)
11. Spicules 130 to 140μ, distal ends recurved ending in sharp points and with three projections on inner side of each spicule.....*Trichostrongylus ransomi*
Spicules equal, 135 to 145μ; distal end of spicules not provided with projections as above.....*Trichostrongylus colubriformis*
12. Spicules with multiple tips; gubernaculum present..*Graphidium strigosum*
Spicules with simple tips; gubernaculum absent.....(13)
13. Lobes of bursa rounded; medio- and postero-lateral rays parallel.....(14)
Lobes of bursa triangular; medio- and postero-lateral rays divergent.....(15)
14. Spicules ending in a finger-like process.....*Nematodirus leporis*
Spicules ending in a sharp point.....*Nematodirus neomexicanus*
15. Combined length of muscular portions of ovejectors including sphincters 800 to 850μ; vulva 3.6 to 4 mm. from tip to tail .....*Nematodirus triangularis*
Combined length of muscular portions of ovejectors including sphincters 500 to 520μ; vulva 2.0 to 2.2 mm. from tip to tail.....*Nematodirus arizonensis*
16. Genetalia of the female single.....*Longistriata novibariae*
17. Esophagus not dilated posteriorly into a bulb.....(18)
Esophagus dilated posteriorly into a bulb .....(19)
18. Head without lips or a cephalic collarette; parasites usually of leg joint.....*Dirofilaria scapices*
Head with two lips and a cephalic collarette; parasites of the stomach.....*Physaloptera* sp.
19. Males with a circular preanal sucker, with a chitinous rim; caudal alae supported by 12 pairs of papillae; eggs thick-shelled, ellipsoidal....*Heterakis gallinae*
Males without preanal sucker; eggs thin-shelled, ellipsoidal.....(20)
20. Posterior end of male short and blunt, with row of transverse comb-like crests on ventral surface; bulb not separated from rest of esophagus by constriction.....*Dermatoxys veligira*
Posterior end of male long and pointed; no comb-like crests; bulb separated from rest of esophagus by constriction...(21)
21. Gubernaculum present; vagina usually extruded through a cuticular tube which projects from body of worm and vulva occurs on end of the tube.....*Wellcomia evoluta*
Gubernaculum absent; vagina not extruded through a tube.....(22)
22. Tail of old females with circular cuticular thickenings; males with more than two pairs of circum-anal papillae.....*Passalurus ambiguus*
Tail of old females without cuticular thickenings; males with two pairs of circum-anal papillae.....*Passalurus nonanulatus*

LITERATURE CITED

1. ALICATA, JOSEPH E. 1929. The occurrence of *Dirofilaria scapiceps* in rabbits. Jour. Parasitol., 15: 287.

2. ARNOLD, JOHN G., JR. 138. A study of the Anoplocephaline cestodes of North American rabbits, Zoologica, **23**: 31–35.
3. 1941. A new rabbit nematode, *Stunkardionema halla*. Amer. Micros. Soc. Trans., **60**: 65–68.
4. BAER, J. G. 1927. Monographie des Cestodes de la famille des Anoplocephallidae. Bul. Biol. France et Belg. Suppl., **10**.
5. BELL, J. F. and W. S. CHALGREN. 1943. Some wildlife diseases in the eastern United States. Jour. Wildl. Mgt., **7**: 270–278.
6. BLAIR, F. 1936. The Florida marsh rabbit. Jour. Mammalogy, **17**: 197–207.
7. CHADDOCK, T. T. 1938. Some facts concerning cottontails imported into Wisconsin. Wisc. Conservation Bul., **3**: 49–52.
8. CHANDLER, ASA C. 1929. A new species of trematode worms belonging to the genus *Hasstilesia* from rabbits in Texas. Proc., U. S. Natl. Mus., **75**: 2792.
9. CHEATUM, E. L. 1943. Parasites of cottontail in New York (no exact title given.) Pittman-Robertson Quarterly, **3**: 194–196.
10. CLANCY, CARL F., ERVIN JUNGHERR, and PALMER R. SIME. 1940. Internal parasites of cottontail rabbits in Connecticut. Jour. Wildl. Mgt., **4**: 162–168.
11. CURTICE, COOPER. 1892. Parasites, being a list of those infesting the domesticated animals and man in the United States. Jour. Comp. Med. and Vet. Arch., **13**: 223–236.
12. DALKE, PAUL D. 1937. A preliminary report of the New England cottontail studies. Trans. No. Amer. Wildl. Conf., **2**: 542–548.
13. 1942 (1943). The cottontail rabbit in Connecticut. Hartford, Conn. Public Document 48. 93 pp.
14. DANHEIM, BERTHA L. 1924. A new nematode of the rabbit. Anat. Rec., **29**: 124.
15. DIKMANS, G. 1935. New nematodes of the genus *Longistriata* in rodents. Jour. Wash. Acad. Sci. **25**: 72–81.
16. 1937a. Two new species of the nematode genus *Nematodirus* (Trichostrongylidae) from rabbits. Proc. Helminthol. Soc. Wash. **4**: 65–67.
17. 1937b. A note on the members of the nematode genus *Trichostrongylus* occurring in rodents and lagomorphs, with descriptions of two new species. Jour. Wash. Acad.Sci. **27**: 203–209.
18. DOUGHERTY, ELLSWORTH C. and FRANS C. GOBLE. 1946. The genus *Protostrongylus* Kamenskii, 1905 (nematoda: Metastrongylidae) and its relatives: Preliminary note. Jour. Parasitol., **32**: 7–16.
19. DOUTHITT, HERMAN. 1915. Studies on the cestode family Anoplocephalidae. Illinois Biol. Monogr., **1**(3): 1–96.
20. FLANNERY, WILLIAM A. 1936. Studies on the trematode. *Hasstilesia tricolor*. Ohio State Univ. Thesis.
21. GOBLE, FRANS C. and E. H. CHEATUM. 1944. Notes on the lung worms of North American Leporidae. Jour. Parasitol., **30**: 119–120.
22. GRAYBILL, H. W. 1924. A new species of roundworm of the genus *Trichostrongylus* from the rabbit. Proc. U. S. Natl. Mus., **66**: 1–3.
23. HALL, M. C. 1908. A new rabbit cestode, *Cittotaenia mosaics*. U. S. Natl. Mus. Proc., **34**: 691–699.
24. 1916a. *Hasstilesia tricolor* (Stiles and Hassal, 1894). A common parasite of rabbits in the United States. Jour. Am. Vet. Med. Assoc., **4**: 453–456.
25. 1916b. Nematode parasites of mammals of the orders Rodentia, Lagomorpha, and Hyracoidea. Proc., U. S. Natl. Mus. **50**: 1–258.
26. 1920. The adult taenioid cestodes of dogs and cats and of related carnivores in North America. Proc. U. S. Natl. Mus. **55**: 1–94.
27. HARKEMA, REINARD. 1936. The parasites of some North Carolina rodents. Ecolog. Monog., **6**: 151–232.
28. HAUGEN, ARNOLD O. 1943. Life history studies of the cottontail rabbit in Southwestern Michigan. Am. Midl. Nat., **28**: 204–244.
29. HENDRICKSON, GEORGE O. 1937. The Mearn's cottontail in Iowa. Trans. No. Amer. Wildl. Conf., **2**: 549–554.
30. HERMAN, CARLTON M. and H. A. JANKIEURCZ. 1843. Parasites of cottontail rabbits on the San Joaquin Experimental Range, California. Jour. Wildl. Mgt., **7**: 395–400.

31. HICKIE, PAUL. 1940. Cottontails in Michigan. Lansing, Mich. Dept. Conserv., 112 pp.
32. HONESS, R. F. 1935. Studies on the tapeworms of the Black Hills cottontail rabbit, *Sylvilagus nuttalii grangeri* (Allen with special reference to the life history of *Cittotaenia variabilis* Stiles. Univ. Wyoming Pub. Sci., **2**: 1–10.
33. JEWELL, MINA E. 1925. *Cysticercus pisiformis* in the lungs and pericardium and beneath the costal pleura of a rabbit. Jour. Parasitol., **12**: 119.
34. KRULL, WENDELL H. 1933. New snail and rabbit hosts for *Fasciola hepatica* Linn. Jour. Parasitol., **20**: 49.
35. LE DUNE, E. K. 1933. A survey of the parasites infecting the wild rabbit *Sylvilagus floridanus*, of Ohio. Ohio State Univ. Thesis.
36. 1935. State of New York. Conserv. Dept. 25th Annual Report, pp. 307–314.
37. 1936. State of New York, Conservation Dept. 26th Annual Report, pp. 307–314.
38. LEIDY, JOSEPH. 1886. Notices of nematoid worms. Proc. Acad. Nat. Sci. Phil. **38**: 308–313.
39. LLEWELLYN, LEONARD M. and C. O. HANDLEY. 1945. The cottontail rabbits of Virginia. Jour. Mammalogy, **26**: 379–390.
40. LYMAN, R. A. 1901. Studies of the genus *Cittotaenia*. Trans. Am. Micro. Soc. **23**: 173–190.
41. MCCLURE, G. W. 1932. Nematode parasites of mammals. Zoologica, **15**: 49–60.
42. MEGGITT, F. J. 1924. Cestodes of mammals. London, 282 pp.
43. MOORE, EUGENIA RUTLAND. 1939. The helminth parasites of cottontails in the vicinity of Auburn, Alabama. Alabama Polytechnic Institute Thesis. (Abstracted in Wildlife Review No. 23, Oct. 1939).
44. MORGAN, B. B. and E. F. WALLER. 1940. A survey of the parasites of the Iowa cottontail (*Sylvilagus floridanus meansi*). Jour. Wildl. Mgt., **4**: 21–26.
45 NOBLE, WILLIAM and SEPTIMA SMITH. 1932. *Hasstilesia tricolor* Stiles and Hassall, 1894—A new report. Science **76** (1966): 216.
46. PRICE, EMMETT W. 1928. List of helminth parasites occurring in Texas. Jour. Parasitol., **14**: 200–201.
46a. RANKIN, JOHN S., JR. 1946. Helminth parasites of birds and mammals in western Massachusetts. Am. Mid. Nat., **35**: 756–768.
47. RANSOM, B. H. 1911. Two new species of parasitic nematodes. Proc. U. S. Natl. Mus. **41**: 363–369.
48. ROZYCKI, ANTHONY T. 1941. Studies on the intestinal nematodes of the cottontail rabbit. Minnesota Univ. Thesis.
49. SCOTT, JOHN W. 1943. A new lungworm from the Leporidae *Protostrongylus sylvilagii*, n. sp. Wyoming Univ. Pub. **10**: 57–71.
50. SCOTT, J. W. and R. HONESS. 1932. An important lungworm of rabbits in southeastern Wyoming. Colorado—Wyoming Acad. Sci. Jour., **1**: 60.
51. SMITH, A. J. 1908. Synopsis of studies in metazoan parasitology in McManus laboratory of pathology, University of Pennsylvania. Univ. Penn. Med. Bul., **20**: 262–282.
52. SMITH, CHARLES C. 1940. Notes on the food and parasites of the rabbits of a lowland area in Oklahoma. Jour. Wildl. Mgt., **4**: 429–431.
53. SMITH, R. H. and E. L. CHEATUM. 1944. Role of ticks in decline of an insular cottontail population. Jour. Wildl. Mgt., **8**: 311–317.
54. STILES, CH. WARDELL. 1896.A revision of the adult tapeworms of hares and rabbits. Proc. U. S. Natl. Mus., **19**: 145–235.
55. STILES, CH. WARDELL and ALBERT HASSALL. 1894a. A new species of intestinal fluke (*Distoma tricolor*) in the cotton-tail rabbit (*Lepus sylvaticus* Bachman) and the northern hare (*L. americanus* Erxleben.) The Vet. Magazine, **1**: 729–737.
56. 1894b. Nouvelle espece de douve intestinale (*Distomum tricolor*) chez le lapin queus catonneuse (*Lepus sylvaticus* Bachman) et chex le lievre du nord (*Lepus americanus* Erxleben). Bul. Soc. Zool. de France, **19**: 160–162.
57. TOMKINS, IVAN R. 1935. The marsh rabbit: An incomplete life history. Jour. Mammalogy, **16**: 201–205.

58. WARD, J. W. 1934. A study of some parasites of rabbits of Central Oklahoma. Proc. Okla. Acad. Sci. **14**: 31–32.
59. WHITLOCK, S. C. 1939. Infection of cotton-tail rabbits by *Cysticercus pisiformis* (*Taenia pisiformis*). Jour. Wildl. Mgt., **3**: 258–260.
60. WHITLOCK, S. C. and CARL GOWER. 1938—Tapeworms in rabbits. Michigan Conservation, **8**(2): 8.

THE HURON MOUNTAIN DEER HERD

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The Huron Mountains of northern Michigan lie immediately south of Lake Superior in the extreme northwest corner of Marquette County. The region contains some of the most rugged country, as well as some of the finest remaining stands of virgin timber, in the state. A private organization, the Huron Mountain Club, controls some 15,000 acres in this area. From October 1939 until July 1942, during which time nineteen months were spent in the field, a wildlife survey was made of this tract. Certain data were gathered concerning the white-tailed deer, *Odocoileus virginianus borealis* Miller, which it seems worthwhile to record here.

Deer occur throughout the Huron Mountains, but during the periods of deep snow and low temperatures they congregate in a tract from approximately one to four miles wide, below the hills and generally skirting the shore of Lake Superior, where the snow depth is usually considerably less than farther inland. This concentration is usually in effect from early January through March. During this time, deer are seldom seen more than a hundred yards or so from coniferous cover, be it lowland white cedar swamps or upland hemlock or pine. Travel at this time is largely by well-worn trails, some of which traverse several miles.

The rutting season in the Huron Mountains occurs from about the end of October into early December. Most of the fawns are dropped between May 25 and June 13. The molt to the rich, reddish summer coat took place from June 2 to 16, 1940; the "blue" winter pelage appeared from September 10 to 24, 1940.

Deer have not always been so plentiful in the Huron Mountains as at present. Hubbard (1887: 356) wrote: "The American deer . . . was not known in our upper peninsula, on Lake Superior, as late as 1840, nor until driven northward by the persecution of hunters." With the clearing of the lands deer became established, but slowly at first. Shiras (1936: 205) wrote: "In 1870, when I first went to the Marquette region, . . . few were to be found within a mile of the south shore" [of Lake Superior]. Within the next decade the invasion was rapid. Shiras (*loc. cit.*) recorded the killing of 80,000 deer in each of the years from 1879 to 1881, mostly "within ten miles of Lake Superior." In the Huron Mountains,

Carter H. Harrison recalls that about 1890 deer were nearly five times as numerous as today, a decline starting about 1912. Oliver Morris remembers them as plentiful about 1900. Gottlieb Rudat stated that when he first came to the region, in 1903, there were seemingly fifteen deer to each one at present. Daniel L. Hebard reported deer at their height in the Huron Mountains about 1910, and falling off by 1913. William P. Harris, Jr., feels that another increase has been in progress since about 1913, reaching its height in 1929 or 1930.

In recent years various individuals have made estimates of the size of the deer herd on the lands of the Huron Mountain Club. H. Emerson Tuttle estimated 100 deer in 1935. Fred L. Dunham, during the same year, estimated from 250 to 300 deer; he increased his figure to 400 in 1936, and to 500 in 1937. In March 1938, Adolph M. Stebler reached a figure of 150 to 200 deer on these lands. An estimate was made by the author of 225 deer during March 1940. A deer drive, enlisting the aid of ninety-one people, was made over an area of 480 acres of apparently typical winter deer range on August 19, 1941. Sixteen deer were counted (14 does and yearlings, 1 buck, 1 fawn—although these groupings are not reliable). On this basis there were 350 deer on all the Club lands, representing a density of 21.6 deer per square mile. Eighteen deer per square mile was the average throughout the Upper Peninsula of Michigan in deer country (Bartlett, 1938).

Such a concentration of deer is far greater than the carrying capacity of the lands. Available food during the winter is the critical factor in the survival of the deer herd. Ground hemlock or American yew (*Taxus canadensis*), a preferred deer food, has long since disappeared in the Huron Mountains. Dodge (1918) reported it "in hardwoods near Huron Mountain Club. Plentiful throughout." It is still abundant on the nearby Huron Islands, where no deer occur, but on the mainland it has been nearly extirpated. I know of only six remaining stands, small patches out of reach of the deer. Throughout the winter deer range there are distinct browse lines on white cedar, hemlock, and balsam fir; maples and basswood also show heavy use.

The natural winter deer foods in the Huron Mountains, as I observed them from January 22 to April 15, 1940, and from January 28 to February 10, 1941, are listed in Table 1. Availability is rated as abundant, common, or sparse on the basis of the relative winter supply available to the deer in their winter range. Palatability, rated as high, fair, or low, is merely estimated from an impression of the deer's choice of each food in the wild. Palatability does not necessarily indicate nutritional value, although there probably is a high degree of correlation between the two. Utilization is a function of both availability and palatability, and indicates the relative importance of the different foods to the deer's winter diet in this region. On eight specific days during the winter concentration of deer, in the course of cruising the deer territory, counts were kept of individual trees or shrubs recently browsed by deer; figures given are the total number of such observations on these eight days. It is felt that figures over 100 give a

TABLE 1.—NATURAL WINTER DEER FOODS IN THE HURON MOUNTAINS

Species	Parts eaten	Availability	Palatability	Utilization
STAPLE DIET				
Hemlock, *Tsuga canadensis*	Foliage, twigs, bark	Abundant	High	546
Sugar maple, *Acer saccharum*	Buds, twigs	Abundant	High	529
Striped maple, *Acer pennsylvanicum*	Buds, twigs	Abundant	High	503
White cedar, *Thuja occidentalis*	Foliage, twigs	Common	High	393
EMERGENCY DIET				
Balsam fir, *Abies balsamea*	Foliage, twigs, bark	Abundant	Low	167
Tag alder, *Alnus incana*	Buds, twigs	Common	Fair	66
Red maple, *Acer rubrum*	Buds, twigs	Common	Fair	52
Yellow birch, *Betula lutea*	Buds, twigs	Common	Fair	32
Willow, *Salix* sp.	Buds, twigs	Common	Fair	23
Red-berried elder, *Sambucus racemosa*	Buds, twigs, stems	Sparse	High	22
Black ash, *Fraxinus nigra*	Buds, twigs	Sparse	High	20
Red-osier dogwood, *Cornus stolonifera*	Buds, twigs	Sparse	High	19
Pin cherry, *Prunus pennsylvanica*	Buds, twigs	Common	Fair	17
Poplar, *Populus tremuloides*	Buds, twigs	Common	Fair	16
Mountain maple, *Acer spicatum*	Buds, twigs	Sparse	High	9
Mountain ash, *Sorbus americanus*	Buds, twigs, fruit	Sparse	High	9
White birch, *Betula alba*	Buds, twigs	Common	Fair	8
White pine, *Pinus strobus*	Foliage, twigs	Common	Fair	8
Basswood, *Tilia americana*	Buds, twigs	Sparse	High	6
Elm, *Ulmus americana*	Buds, twigs	Sparse	High	4
Fly honeysuckle, *Lonicera canadensis*	Buds, twigs	Sparse	High	1
STARVATION DIET				
Norway pine, *Pinus resinosa*	Foliage, twigs	Abundant	Low	—
Jack pine, *Pinus banksiana*	Foliage, twigs	Abundant	Low	—
Red oak, *Quercus rubra*	Buds, twigs, acorns	Sparse	Fair	—
Sweet fern, *Myrica asplenifolia*	Foliage, stems	Sparse	Fair	—
Trailing arbutus, *Epigaea repens*	Foliage	Sparse	Fair	—
Thimbleberry, *Rubus nutcanis*	Buds, stems	Sparse	Fair	—
Wild currant, *Ribes* sp.	Buds, twigs	Sparse	Fair	—
Ground pines, *Lycopodium* spp.	Foliage	Sparse	Fair	—
Wintergreen, *Gaultheria procumbens*	Foliage	Sparse	Fair	—
Mosses	Foliage	Sparse	Fair	—
White spruce, *Picea glauca*	Foliage	Common	Low	—
Ironwood, *Ostrya virginiana*	Buds, twigs	Common	Low	—
Lichens, *Usnea* spp.	Whole plant	Common	Low	—
Beaked hazel, *Corylus rostrata*	Buds, twigs	Sparse	Low	—
Blueberry, *Vaccinium pennsylvanicum*	Foliage, stems	Sparse	Low	—
Labrador tea, *Ledum groenlandicum*	Foliage, stems	Sparse	Low	—
Sweet gale, *Myrica gale*	Foliage, stems	Sparse	Low	—
Leatherleaf, *Chamaedaphne calyculata*	Foliage, stems	Sparse	Low	—
Bog rosemary, *Andromeda glaucophylla*	Foliage, stems	Sparse	Low	—
Bearberry, *Arctostaphylos uva-ursi*	Foliage, stems	Sparse	Low	—
Grasses	Foliage	Sparse	Low	—
Bracken, *Pteridium aquilinum*	Foliage	Sparse	Low	—
Cat-tail, *Typha latifolia*	Down	Sparse	Low	—

reliable picture of a plant's utilization by deer; figures from 20 to 100 offer a fair degree of accuracy; figures below 20 merely indicate that the plant is eaten to some extent. Plants listed, but with no utilization figure given, were observed eaten by deer, but not on any of the eight days when tallies were kept; they were used very infrequently, either because of low palatability or low availability, or both. The foods are grouped as staple, emergency, and starvation diets following the scheme of Leopold (1933: 261).

There are few natural checks on the Huron Mountain deer herd. Predation appears to be slight. In 1937 and 1938 twenty-three dead deer were found by Fred L. Dunham; he attributed sixteen of the deaths to wolves and one to bobcats. From 1939 to 1942 I found eight dead deer; two were struck by automobiles, but the cause of death of the others was undetermined. Despite the crowded conditions, the deer appeared to be healthy in 1941. Nine fresh samples of deer droppings were collected on August 10 of that year; subsequent examination by Dr. Earl C. O'Roke disclosed lungworms in four and liver fluke eggs in one of the samples; all the infections were light. Deer killed during the hunting seasons of 1939 to 1941 were in good condition, averaging 158 pounds dressed weight (hunters' estimates of bucks). The numbers of hunters participating and the kills during these three seasons were as follows: 1939—121 hunters, 33 legal bucks; 1940—142 hunters, 53 legal bucks; 1941—211 hunters, 51 legal bucks, 10 legal antlerless deer, and 15 illegal deer.

LITERATURE CITED

BARTLETT, ILO H. 1938. Whitetails, presenting Michigan's deer problem. Bull. Game Div., Mich. Dept. Conser., 1–64.

DODGE, CHARLES KEENE. 1918. Contributions to the botany of Michigan. Misc. Publ. Mus. Zool. Univ. Mich., No. 5, 1–44.

HUBBARD, BELA. 1887. Memorials of a Half-century. New York and London, G. P. Putnam's Sons. xvi+581, illus.

LEOPOLD, ALDO. 1933. Game Management. New York and London, Charles Scribner's Sons, xxi+481, illus.

SHIRAS, GEORGE, 3D. 1936. Hunting wild life with camera and flashlight. Vol. 1, Lake Superior Region. Washington, Nat. Geog. Soc., xxiv+450, illus.

SPECIAL ARTICLE

A QUESTION OF VALUES

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Over and over again, practitioners in the professional field of wildlife management are asked, and ask themselves, exactly what they work for. To increase game, to make hunting easier, to control pests, to hold their jobs, or what?

Among other things, I suppose that I may be classed as a wildlife manager, having made a living for nearly twenty years by doing research on game birds and fur-bearers and having published findings that presumably apply to what is known as management of those species. Like my co-workers in the field, I have been asked, and have asked myself, basic questions.

I am pleased when good use is made of my research by conservation commissions and other practical agencies. Yet, if I felt that I merely worked for a salary and to provide more game for hunters to shoot or more fur for trappers to catch, I probably would not want to remain in the profession. If I didn't feel that I might be working for something more important than my own or any other person's selfish advantage, a drudgery and strain that I have come to accept as an unavoidable accompaniment of my life-work would be burdensome, indeed.

I am in no position to undertake here a comprehensive discussion of human motivations, in the field of wildlife management or out of it. I had even better leave out of consideration some very strong scientific and sociological motivations and restrict this essay in scope to a few aspects suggesting denominators common to wildlife managers and, let us say, the hunters and trappers.

From early youth to mid-twenties, or up to the beginning of my graduate training, I earned my living largely by fur-trapping. This was my recognized vocation, and it usually paid off in cash as well as any other that I could have had at the time. But some of the trapping seasons that I enjoy recalling were among the less profitable economically. My two most ambitious expeditions (which in the end perhaps yielded me as much enduring satisfaction as anything I ever did as a young man) were business failures. Moreover, the drawbacks of a trapper's life as I lived it ruled out money as a full explanation for the attraction trapping may hold for civilized men. Nor am I convinced that prospects for adventure are any more of an explanation. Part of the answer lies in intangibles, in chickadees fluffing themselves into feathery balls and tree trunks popping in the northwoods cold, in grouse budding in aspen thickets at dusk, in sun dogs hanging over the western plains, in clean air and freedom, and in the sweet loneliness expressed by passages in Sibelius' "Finlandia."

I was also a hunter during my trapping years. I won't lay claim to having been the idealized sportsman of whom I read in outdoor magazines. I wasn't, and I shot more for meat than for

sport, but, at any rate, I know the hunter's side of hunting.

In the eastern South Dakota of my upbringing were chain after chain of glacial lakes, marshes, and potholes, with ducks in variety and numbers possibly not found anywhere on earth since the decade following the first World War. Like other hunters, I have my memories of the folding of birds singled out of flocks whipping over the rushes, of the impacts of falling bodies on the water, of drifting feathers and the smell of powder smoke.

For all of that, I must confess that my hunting memories are not as a rule memories of shooting or of bag limits.

One October afternoon, I sat on a ridge between two of the Tetonkeha Lakes adjoining our family's home farm. The day was warm and still, and I saw only scattered, high-flying ducks until sundown. Then, a redhead flight started from the west. The birds were flying out of shotgun range, so I just continued to sit. Flock following flock, the sound of their passage roared over land and water like the sound of an express train crossing a trestle. I doubt not that I was disappointed to go home without any of those ducks, but the vision that stays with me is one of the color and power of the redheads pouring down onto the lake.

Another occasion on which there was more shooting comes to mind. The numbers of waterfowl I saw on a raw, windy day at Lake Albert in 1927 hardly compared with those to be seen when my grandparents lived in their sod shanty in the Tetonkeha hills, nor with the numbers existing in my childhood when men would come home with all of the ducks they could carry and guns would flash on the marshes late into the evening. Nevertheless, on this day, there were in view on the horizon mallards in flocks of hundreds and thousands, and these were interspersed by an unending succession of smaller flocks and stragglers. The ducks that furnished our shooting were mainly lesser scaups.

The scaups were high, wide, and fast; they were low, close, and fast; they came tumbling and zigzagging down from the heights on slanted wings to skim over the water; they swept by in compact bunches or in open arcs or in irregular formation. The shooting was extremely "sporty," though attended by exasperating losses of dead and crippled birds because of the roughness of the water. Now, I find that day most pleasing in retrospect if I simply think of ducks in the air.

Nor do all of my hunting memories relate to panoramic spectacles. I recall a day spent along the Sioux River, west of Brookings, South Dakota. I don't know what my bag was but it wasn't large—a mallard brought down by a lucky snapshot through an opening in the tree tops, a green-winged teal, and maybe a couple of cottontail rabbits. I don't remember what else, if anything, I may have shot and don't care to. What I do remember was the contrast of the white wedge on the dark head of a hooded merganser swimming in a patch of open water. I stood watching it from the underbrush until it saw me and took wing, to disappear around the bend and to leave to me the empty setting of water and wet snow.

Memories arise that are still more gunless, of the slow wing beats and sailing of white pelicans; of curlews,

avocets and hosts of smaller shorebirds; of muskrats floating on the marshes at sunset, their tails crooked in the air. There are memories of spawning pickerel in the shallows and herons standing along the lake shores and ground squirrels in the pastures. There are memories of ordinary and trivial things.

Ordinary or trivial as may be the substance of these memories, they are my prize trophies from the out-of-doors. How much the values underlying them may be identified with James Norman Hall's "spirit of place" I am not sure, but unquestionably they are of it. One spring day long after my trapping years, I walked the banks of a creek familiar to my youth and was depressed because of having seen no mink tracks on mud bars where I knew there should have been some. Those mink tracks, in my mind, were integral to the "spirit of place" of that creek, and no amount of the crowing of introduced pheasants could compensate for their lack.

Nostalgia doubtless enters into the equation, but again I can not say how much. The pronghorn antelope, the anhinga, the limpkin, the sage grouse, and the woodland caribou were not creatures of my early background; and I have never seen living in the wild a musk-ox, polar bear, black-footed ferret, or ptarmigan. Even so, I don't believe that I fail to appreciate how unmistakably they may belong in their respective habitats. One may easily go on and list at random almost any number of organisms, plants and animals, similarly belonging in their own biotic communities: flying squirrels in aspen stubs, white-footed mice climbing in the underbrush, cypress draped with long moss, ant lions under sandstone bluffs, fungi and crawling life under dead leaves.

Whether or not I ever again do any fur-trapping, I am still a hunter and dream of spending my declining days amid an abundance of game sufficient for me to shoot some of it without feeling ashamed of myself. As a hunter, I am interested in management programs having promise for increasing the game I like to hunt. That can be acknowledged without implying that my enthusiasm for a given program is proportional to the success with which it may increase the game, irrespective of damage to other outdoor values resulting from the means employed.

To me, with gun in hand or without, the appeal of the out-of-doors seems chiefly conditioned by the relative diversity and completeness of its native fauna and flora and the naturalness of its topography.

Although we may not anticipate a general return of bison herds to the central plains of North America as long as we retain our present social and economic system, the perpetuation of much of our natural out-of-doors is not incompatible with modernity. The growing literature on integration of ends for sound and permanent land use contradicts the thesis that "progress" must inevitably be accompanied by what we have been pleased to call the "conquest of nature," with its top-heavy artificialities and its wastefulness.

Many of the problems of conservation and management are vexatious and appallingly involved. It is not hard to understand why conservation or management practice (or policy) has

not been free from confusion and cross purposes or how it may be guided less by long-time than by immediate objectives. In common with other human endeavors, conservation or management probably always will be attended by its share of futility and short-sightedness. Regrettable though this may be, worse still is the outright destruction of the values needing most to be preserved—especially in management programs sponsored by agencies subject to public pressure or catering to circumscribed groups.

It is fitting to strive for "business-like" efficiency in wildlife management and to take aggressive action to stay or reverse the forces that impoverish the continent. Management, in the sense of judicious manipulation both of organisms and of their environment, should be legitimate and desirable as long as the price is not too great.

The chief mistakes in management practice that I have seen in my professional experience fall in two categories. The writings of Aldo Leopold and O. J. Murie have dealt with the first—the "cleaning up" and "doctoring" of places that should be left alone. The opening of roads, the cutting of grass, brush, and dead trees, the thinning of timber, the planting of exotic vegetation, the building of feeding stations, shelters, and bird houses, the breeding of wild animals in pens, are proper activities of man but they should not be carried on everywhere; and, whenever man's ancient weakness for painting lilies becomes translated into artificializing in the name of wildlife management the remnants of natural out-of-doors that some regions have left, we need to take our collective bearings. What if a wilderness be comparatively unproductive in game yields or commercial assets if its own intrinsic values outweigh the ones it might conceivably gain through artificial changes?

Not many years ago, I visited an island in a marsh, and my first impression was one of exceptional solitude and wild beauty, of a place where, despite the surrounding farm lands, a person wanting relief from human banalities might enjoy an illusion of remoteness. The illusion, however, could not withstand the reality of the series of game shelters that had been cut out of the island's trees.

In the second category of mistakes falls a vast amount of the "control" of native vertebrates advocated or conducted by this or that faction.

The traditional emphasis placed by sportsmen upon campaigning against the predatory or competitive species they designate as "vermin" is seldom based on adequate studies. In too many instances, it betrays the confusions introduced by mixed variables and cherished "fallacies of misplaced concreteness." Predation and competition being manifestations of life are, like life, phenomena of multitudinous complexities that do not always work out as it may be taken for granted that they should. Suppression of predators or of competitors does not necessarily mean benefit to the game or more game to shoot; it is not a panacea and on the whole—not entirely—shows less promise with investigation.

If, however, "vermin control" had many times over the effectiveness ascribed by its proponents, its use as an instrument of game or wildlife management would be no less in need of tem-

pering with moderation and discrimination. Let it be understood that among the so-called vermin are some of our most beautiful and valuable of wild creatures. They comprise a resource demanding sane administration as much as any class of wildlife.

At its worst, "vermin control" may be carried on with an almost unbelievable pointlessness and intolerance. One may scarcely bring to mind a living thing larger than a tree frog that is not "vermin" to someone—including game species in alleged behalf of which someone else may be shooting up the out-of-doors. I have seen hunters deliberately trying to shoot every shoveller—an easily killed duck and one greatly reduced a few years back—that came within gunshot, to leave the carcasses where they fell, with remarks that the birds weren't fit to eat and ought to be cleaned out.

The coyote, the crow, and other adaptable and widely distributed predators are not the ones that are endangered by the anti-"vermin" crusades and the ceaseless killing as opportunities offer. It is the irresponsible harassment of species that "can't take it" that should cause us the most concern—the raptorial and fish-eating birds of restricted geographic range or of strikingly diminished numbers, the predatory fur-bearers that are gravely enough depleted by over-trapping and shrinkage of habitats, the slow-breeding, the unwary, the bizarre, the big and tempting targets. Luckless may be the rare or waning species that concentrates conspicuously in localities where it is vulnerable to raiding by man, notably if it be charged with "harmful" habits.

In my opinion, it is highly dubious strategy to propagandize in favor of mass action for the "control" of native predators, to accelerate wholesale persecution by contest awards, bounties, and the sanction of influential organizations. The prejudices against wild flesh-eaters are so entrenched in people's minds that encouragement may invite excesses and further squandering of what we may not have to spare. When even school children are urged to go out and kill an interminable variety of wild animals as "vermin," we should not be surprised at the peculiar turns that love of the out-of-doors may take.

Writing as a hunter, I would say that sport purchased at disproportionate cost to other outdoor values is not worth having. Wildlife management will be found very much wanting if it fails to safeguard any but popular game species and, incidentally, the song birds and unnoticed forms that are likely to thrive, anyway.

Hunter though I am, why should I have to be one to gain caste, to be entitled to more than outdoor left-overs that may escape gun or pole-trap? Why should I not dawdle on a hill top in the hazy autumn sunshine if I would rather do that than go hunting, and, if I choose not to hunt, why should it follow that I automatically relinquish to hunters all of my rights in game or in wild animals associated with game? To the extent that I as a citizen am mindful of the courtesies due others, I think that I should be entitled to a certain freedom in my choice of outdoor pleasures, without carrying the insignia of gun any more than of rod or field glass or camera or hiking kit. If management itself is to be in analysis anything except exploitation, it must guard against

the fundamental wrongness of giving me, upon payment of a piddling license fee, more shooting privileges than I deserve, at the same time short-changing me as a citizen.

Herein lies a most serious obstacle to harmonious cooperation of outdoor groups in matters that should be to their mutual interest. The harvesting of a seasonal game crop through hunting isn't always the bitterest source of dissention between sportsman and "protectionist." Far more may be attributed to the blindness and selfishness of too many of the sportsmen and their leaders and their assurance that not only is the game theirs to shoot if they want to but also that theirs is the prerogative of doing about whatever they may wish with wildlife in general.

Flatly, I would say that it is time for hunters to reappraise their position in terms other than what they can get by with. I regard hunting logically justifiable only in so far as it may be done without real detriment to both game and non-game species, which means in short that the hunting toll (bagged and lost) of a given species be pretty well confined to biological surpluses. If I were to continue to hunt a severely declining species—though the primary cause of the decline be something besides shooting—I would consider myself justly entitled to less rights than the non-shooters. It is perfectly fair to expect me as a hunter to make concessions when that is the decent thing to do, as during emergency crises, the depressed phases of periodic cycles, years of overshooting, etc.

Of course, this, too, reflects in part my philosophy as a wildlife manager. It may or may not be that of others, but at least the profession could rightly accept something of the broader responsibilities implied by the leadership it exerts and the degree of custody it in effect holds over outdoor values that are not to be reckoned as material harvests. The issue is not one of management versus no management, but rather of what management should be and where it should be done; the criteria of accomplishment may be conformity to good taste as well as statistical impressiveness.

Within reason, we and our editorialized but cheated posterity should be able to think of wildernesses extending beyond highways, of barren grounds and ice-fields and deserts and unlogged forests and untampered lakes and streams. We should know of marshes with sandhill cranes and the more retiring of water birds, of rivers where otters live, of mountains where martens, fishers, wolverines, cougars, wolves, grizzly bears, and native sheep and goats exist in some security. Close to home, we should be able to find natural retreats in appropriate places, to see an eagle, osprey, loon, or one of the larger falcons on occasion; still to watch, among the sights that belong, the red-tailed hawk in the sky; still to hear, among the night sounds, the hooting of the horned owl in the woods.

THE WILDLIFE SOCIETY

Report of the Secretary as of April 4, 1947

The past year has been a very busy one for the Secretary, the other officers, and the Regional Representatives. The expansion and reorganization of wildlife agencies has offered us the opportunity to provide the Journal of Wildlife Management, the Wildlife Society News-Letter and other benefits to ever-growing numbers of wildlife workers and patrons.

As of April 4, 1947, 484 Active members and 555 Associate members, a total of 1,039, have paid dues for 1947. Thus far during the fiscal year, we have taken in 100 new Active members. This required efficient work by the Membership Committee and the Council. At the present time, there are 22 pending Active members being considered by the Membership Committee. During the same period, 252 new Associate members joined the Society. One new Life member joined during the past year. Our membership has reached an all-time high this year. At present, there are 52 Actives and 85 Associates in arrears for 1947. It is highly probable that most of them will pay up in the near future. During the year, 4 Actives and 1 Associate resigned.

Following are listed the new Honorary, Life and Active Members:

New Honorary Members

Seth Gordon
Hoyes Lloyd
Sydney Stephens

New Life Member

Urban C. Nelson

New Active Members

John M. Allen
Maurice M. Alexander
G. A. Ammann
Lester Bagley
Rollin H. Baker
Robert C. Ball
Frank B. Barick
P. G. Barnickol
Aden C. Bauman
Stephen L. Beckwith
Watson E. Beed
Lester M. Berner
Harris G. Breth
Charles R. Buller
Irvin O. Buss
John B. Calhoun
R. E. Callendar
John M. Carlisle
John E. Chattin
Dennis Chitty
Richard J. Costley
Richard H. Cross, Jr.
Clarence F. Culler
Roland E. Curtis
Everett T. Dawson
Lawrence Dayton
Roland E. Dimick
K. H. Doan
Howard D. Dodgen
Donald W. Douglass
Frank W. Eatman
Arthur B. Eustis
Lester F. Faber
Reed W. Fautin
Edson Fichter
C. David Fowle
Marshall C. Gardner
Paul F. Gilbert
William E. Ginn
Fred A. Glover
Harry A. Goodwin
Earl J. Gordinier
Albert E. Hall, Jr.
Frank D. Haller
H. Gordon Hanson
William J. K. Harkness
Archie D. Hass
Paul R. Highby
Trusten H. Holder
Ralph H. Imler
Reuel G. Janson
Oliver M. Jarvenpa
Grant H. Jensen
Frank M. Johnson
Horace D. Jones
Paul V. Jones
Chas. M. Kirkpatrick
F. H. Kortright
Ernest A. Lachner
Roger M. Latham
Joseph P. Linduska
Merwin A. Marston
Kenneth M. Mayall
Robert D. McDowell
Herbert J. Miller
Richard G. Miller
Levi L. Mohler
Gale W. Monson
John S. Morse
Bernard A. Nelson
Eugene P. Odum
Chester F. Phelps
W. Leslie Robbinette
Charles H. Rouse
Arthur D. Schmidt
Thomas A. Schrader
David M. Selleck
Warren W. Shapton
Harry M. Smith
Gerald B. Spawn
Melvin O. Steen
Jerome H. Stoudt
F. W. Stuewer
Wendell G. Swank
Carl V. Swanson
Clayton C. Swears
Walter R. Sylvester
William R. Taber
Peter I. Tack
W. K. Thompson

Howard H. Twinning	George J. Wallace
Lloyd P. Vance	Oscar Warbach
Bruno Von Limbach	H. E. Wells
J. V. K. Wagar	Earl A. Westervelt
Lawr. H. Walkinshaw	Donald J. Woolley

During the past year, the following members died: *Honorary*, Ernest Thompson Seton; *Life*, Ralph Ellis; *Actives*, Walter C. Henderson and Ralph M. Kriebel; and *Associates*, Clinton C. Abbott and Harry B. Hostetter.

The Secretary compiled the list of members in good standing for the October, 1946 issue of the Journal. Arrangements were made for the reprinting of several issues of the Journal to bring our stock of back numbers up to a fairly good level. We have on hand at this time at least 100 copies of every issue. We are now printing 2,000 copies of every issue to insure adequate numbers for future growth of the Society.

In March, 1947, The Wildlife Society became a member of the National Resources Council of America.

President English, Miss Elizabeth Getz, and Miss Shirlee Boal have aided the Secretary greatly in carrying on the Society work.

LOGAN J. BENNETT, *Secretary*

REPORT OF THE BUSINESS MEETING OF THE COUNCIL

The Council of The Wildlife Society called its annual business meeting to order at 2:00 P.M., February 2, 1947, Plaza Hotel, San Antonio, Texas. The following items of business were discussed and acted upon:

Drs. P. F. English: D. I. Rasmussen, and Richard B. Miller were appointed to the Membership Committee, English to continue as Chairman.

Mr. Herford Naylor Elliott was appointed Trustee to replace C. T. Voorhies. Elliott's term is to expire in 1950.

The Council unanimously agreed to submit to the annual business meeting on February 3, the names of Seth Gordon, Sydney E. Stephens and Hoyes Lloyd for consideration for Honorary Membership.

The Council agreed unanimously to submit to the Membership at an early date an amendment to the Constitution to vote upon to raise the subscription rates of the Journal of Wildlife Management from $4.00 to $5.00 a year. Such an increase in subscription rates would not apply to memberships.

The Council agreed unanimously to present an amendment to the Constitution to the membership to vote upon to make it possible to combine the offices of Secretary and Treasurer into one office and have a salaried Executive Secretary. The growth of The Wildlife Society has been steady and the increasing amount of time required to administer the affairs of the Society has almost reached the limit as far as nonsalaried elected Secretary and Treasurer are concerned. If the Society is to continue to grow, some other administration system will be required in the near future.

Charles Dambach was reappointed as Editor of Wildlife Society News-Letter. It was decided that each Re-

gional Representative shall be responsible for getting news to Dambach for the News-Letter.

Douglas E. Wade was appointed as a Committee of one to have drawn up a suitable scroll for the annual recipient of the award for the outstanding Wildlife publication of the year.

Unanimously agreed to become affiliated with the National Resources Council of America at no cost to the Society.

The Council authorized the payment of $50.00 each to the secretaries, Dr. Logan J. Bennett, and Paul D. Dalke, for Society secretarial work during the past year.

The Council approved the proposed budget for the Journal of Wildlife Management as submitted by Dr. Harlow B. Mills, Editor for 1947. The estimated cost of the Journal for 1947 is $4,600.00. The budget for the Wildlife Society News-Letter as submitted by Charles E. Dambach for $600.00 for 1947 was also approved.

The Council tentatively approved a policy for the publication of the ten-year index to the Journal of Wildlife Management. The main point approved being that the index should be made available to members at cost.

The meeting adjourned at 6:30 P.M.

LOGAN J. BENNETT, *Secretary*

The Council approved the following budget for 1947–1948:

		1946 (actual)	
Stationery and printing	$ 250.00	$ 160.64	
Office supplies and equipment	50.00	21.00	
Postage, telegrams, express	200.00	138.08	
Clerical assistance	150.00	0.00	
Editor's expense	50.00	42.45	
Journal of Wildlife Management	4,800.00	3,814.49	
News-Letter	600.00	255.90	
Offset printing of back issues	1,000.00	2,761.88	
Union of Biological Societies	15.00	0.00	
Reprints	50.00	0.00	
Treasurer's expense, 11th N.A.W.C.	0.00	22.58	(Wade)
Trust fund	2,000.00	0.00	
Fidelity bond (treasurer)	15.00	12.50	
Contingency fund	200.00	19.68	
	$9,380.00	$7,249.20	

Balance on December 31, 1946	$ 9,144.74
Estimated receipts for 1947	7,500.00
Total balance & estimated receipts, '47	$16,644.74
Estimated expenditure, 1947	9,380.00
Estimated balance, December 31, 1947	$ 7,264.74

MINUTES OF THE ANNUAL MEETING

The eleventh annual meeting of The Wildlife Society was held February 3, 1947, at 6:30 P.M. at La Villita, San Antonio, Texas, being called to order by President P. F. English. The meeting was preceded by a buffet supper, Mexican style. About 150 members attended.

The President opened the meeting with a few introductory remarks immediately followed by business topics of the evening.

The minutes of the 1946 meeting were dispensed with as they were published in the July 1946 issue of the Journal of Wildlife Management.

The annual report of the Secretary was presented and approved. The Treasurer's report on the finances of the Society was presented by Dr. Paul D. Dalke and accepted. The report on the business meeting of the Council was given by the Secretary and was accepted.

Dr. P. F. English, Chairman of the Membership Committee, gave a report on the work of that committee during the past year. The report showed that the Society has continued to grow in membership and we now have an all-time high in numbers of members.

Dr. George O. Hendrickson, Chairman of Professional Standards Committee presented a report on that committee's work. The report was accepted.

Mr. William J. Howard, Chairman of the Committee on Arrangements presented a fine report to the President on the work of that committee. The report was not read but the program of the conference attested to the good job that the committee did.

Dr. Walter P. Taylor, Chairman of the Program Policy Committee presented a good report on the work of that Committee and it was accepted.

President English announced that the Employment Committee headed by R. M. Rutherford had turned in such a good report that the Council decided to print it in the Wildlife Society News-Letter. This appeared in the January 1947 issue.

Mr. Lloyd W. Swift, the Society's Representative to the National Research Council, presented a report on the activities of that Council. The report was accepted.

Dr. Tracy I. Storer, Chairman of the Awards Committee, named the recipient of the award for the outstanding wildlife publication during the past year. This past year's outstanding article was the one by Paul L. Errington, *Predation and Vertebrate Populations*, The Quarterly Review of Biology, Vol. 21, No. 2, June, 1946, pp. 144–177 and No. 3, September, 1946, pp. 221–245.

By unanimous acclamation, Seth Gordon, Sydney E. Stephens and Hoyes Lloyd were made Honorary members. This distinction was granted these men for their long and outstanding careers in furthering the cause of wildlife conservation.

President English reported on the ten-year index for the Journal of Wildlife Management. A committee, headed by George A. Petrides, has this index well under way. It should be available before our next meeting. The President also reported on a committee to draw up a twelve-year index for the 1935 to 1947 Transactions of the North American Wildlife Conferences. This committee is headed by Dr. Lee E. Yeager. At the San Antonio meeting, Seth Gordon, C. R. Gutermuth, Lee E. Yeager, and your president, decided that the contents of the 15th to 21st Transactions of the American Game Conferences be incorporated in the North American Wildlife Conference Transactions Index. This index is nearing completion and will be included

in the Transactions of the Twelfth North American Wildlife Conference. Place your order early for this transaction with the Wildlife Mamagement Institute, Investment Building, Washington 5, D. C.

The Resolutions Committee, Dr. George O. Hendrickson, Chairman, Howard Zahniser, Richard Gerstell and Tracy I. Storer, submitted the following resolutions which were presented by Hendrickson and approved by the members.

Number 1

WHEREAS the remnants of primitive America are of irreplaceable value to science as sites for fundamental research and as check-areas where none of the human factors being compared by investigators have been operative, and,

WHEREAS the science of wildlife management is peculiarly concerned with the perpetuation of such primitive areas as check-areas against which the practices in game production on lands under management can be measured, and,

WHEREAS the perpetuation of primeval areas with their primitive fauna and flora is threatened by the construction of roads and airplane landing fields, by timber-cutting and mining enterprises, by the impoundment of waters, by the development of intensive recreation facilities, and by other influences of a highly mechanized civilization—

THEREFORE, BE IT RESOLVED that The Wildlife Society in the interest of the science of wildlife management and in the public interest, endorse the movement for for wilderness preservation, commend The Wilderness Society and other conservation agencies for their work in this behalf, and urges the individual members of the Wildlife Society to make known to their political representatives and administrative officials their interests in the preservation of such specific wilderness areas as may from time to time be subjected to immediate threats, and

BE IT FURTHER RESOLVED that copies of this resolution be forwarded by the Secretary to the President of the United States, the Secretary of the Interior, the Secretary of Agriculture, and the heads of the National Park Service, the Forest Service, the Fish and Wildlife Service, the Soil Conservation Service, the Bureau of Indian Affairs, the Bureau of Reclamation, and the Bureau of Land Management.

Number 2

WHEREAS the national system of primitive, roadless, wild and wilderness areas within the national forests are of ever-increasing value to wildlife technologists and other scientists whose research requires access to areas where none of the man-influence factors being investigated have been operative, and

WHEREAS the San Gorgonio Primitive Area in the San Bernardino National Forest in Southern California is an important unit in this system and of unique value in its section, and

WHEREAS the United States Forest Service did on December 11, 1946, give 90-days notice of its intention to eliminate the heart of the San Gorgonio Primitive Area to make way for a highway, hotel-resort, parking area, and ski-tow, and did invite the general participation in a hearing to be held on this issue in San Bernardino, California, on February 19, 1947—

THEREFORE, BE IT RESOLVED that The Wildlife Society urges the United States Forest Service to maintain the San Gorgonio Primitive Area unmodified and offers the Forest Service its support in the maintenance of the policies that safeguard all such primitive areas, and

BE IT FURTHER RESOLVED that copies of this resolution be promptly forwarded by the Secretary to Lyle F. Watts, Chief of the Forest Service, and to Regional Forester P. A. Thompson, 630 Sansome Street, San Francisco, California, with the request that it be presented at the San Bernardino hearing on February 19 and incorporated in the public records of that meeting.

Number 3

WHEREAS much of the best wildlife habitat of the Western States is to be found on Federal lands, and

WHEREAS these lands offer many opportunities for study, restoration and management of wildlife resources, and

WHEREAS the Federal conservation program has been aimed at the adjustment of grazing and other uses so that the soil and water relations can be kept in balance and all public values protected—

THEREFORE, BE IT RESOLVED that The Wildlife Society deplores the program of strong elements of the western livestock industry to gain exclusive use or control of these lands which they are now grazing under permit, or desire to graze, and the Society reiterates its belief that these lands must not be passed on to the control or ownership of any one class of users but must be managed in the public interest, and

BE IT FURTHER RESOLVED that The Wildlife Society urges its individual members throughout the country to be on the alert as to threats to the nation's public land policies and to protest to their political representatives any specific proposed measures that endanger or compromise the public control of lands now in public ownership.

Number 4

THE WILDLIFE SOCIETY at this time desires to thank the Wildlife Management Institute, the State of Texas, and all other individuals and organizations contributing to the success of this Conference for the hospitality and cooperation so evident to all.

The meeting adjourned at 8:00 P.M.

P. F. ENGLISH, *President*
LOGAN J. BENNETT, *Secretary*

REPORT OF BALLOT COMMITTEE

The Committee audited the nomination and election ballots for The Wildlife Society for 1947–48 and found the following:

1. *Nomination Ballots* nominated for *President:* Logan J. Bennett and Thomas H. Langlois; *Vice-President:* Harry D. Ruhl and Tracy I. Storer; *Secretary:* George A. Petrides and Frank C. Edminster (withdrawn); and *Regional Representatives: Region 1:* Allan T. Studholme and Ralph T. King; *Region 2:* Verne E. Davison and Clarence W. Watson; *Region 3:* William H. Marshall and Warren W. Chase; *Region 4:* E. R. Kalmbach and Ralph R. Hill; *Region 5:* W. C. Glazner, A. E. Borell, and Daniel W. Lay; *Region 6:* A. Starker Leopold, James W. Moffett and Paul R. Needham; and *Region 7:* Ian McTaggart Cowan and C. H. D. Clarke.

2. *Election Ballots: President:* Logan J. Bennett; *Vice-President:* Tracy I. Storer; *Secretary:* George A. Petrides and *Regional Representatives: Region 1:* Allan T. Studholme; *Region 2:* Verne E. Davison; *Region 3:* Warren W. Chase; *Region 4:* E. R. Kalmbach; *Region 5:* W. C. Glazner; *Region 6:* Paul R. Needham; and *Region 7:* Ian McTaggart Cowan.

We find the above correct and final as of April 15, 1947.

EDWARD L. KOZICKY
RANDOLPH H. THOMPSON
MERRILL WOOD, *Chairman*

BRIEFER ARTICLES

GERMINATION OF EELGRASS SEED

During the past summer a quantity of eelgrass seed (*Zostera marina*) was harvested for experimental purposes from beds in the Ipswich River, Massachusetts, by personnel of the Parker River National Wildlife Refuge. Since the method used in gathering and storing of seed and observations on germination may be of interest to others, the details are presented in the following note.

In the latter part of August the eelgrass seed was harvested by pulling up fruiting stems on which are borne numerous spathes or capsules containing the seeds. These stems were then placed in a strong copper-screened box (16 meshes to inch) which allowed water circulation and prevented loss of seed. The top of the box was made of quarter-inch mesh galvanized hardware cloth. The screened box containing the fruiting stems was then anchored to the bottom of a small salt creek. The plants were placed in this type of container in order to permit the spathes to decompose and release the mature seeds for winter storage and spring planting.

Although eelgrass seeds readily sink, the spathes containing the seeds float and it would be necessary to remove the seeds by hand if it were desirable to sow them immediately. It is desirable also to have the seed free from the spathe in order to reduce the bulk when stratified between layers of sand for winter storage.

It was not until October 23, that the seed was examined. At this time considerable seed was found in all stages of germination, including the first green leaf stage and the formation of roots. At the time of examination the spathes had rotted sufficiently to permit recovery of the seed by washing through a series of strainers.

The germination of eelgrass seeds and the developing of seedlings before the winter period seems worthy of note. Eelgrass has been spreading rapidly by seedlings under natural conditions. Many eelgrass seeds are mature by the first of August and undoubtedly these seeds and perhaps many of those that are released by September 1, develop into well-rooted seedling plants before the advent of winter.

It has been suggested in the past that eelgrass seed should be stratified between layers of sand in a box and the whole anchored at the bottom of a salt creek for the winter period. Seed stored in this manner will survive the winter in a viable condition but undoubtedly a portion of them will germinate and die before spring.

Experiments are now under way to determine the proper time for planting, whether fall or spring, and the proper method of preparing the bottom.—C. E. Addy, *Parker River National Wildlife Refuge, Newburyport, Massachusetts.*

GUNSHOT WOUNDS IN DUCKS

In the course of investigations on wintering ducks in Michigan during the early part of the winter of 1940–41, the idea of using the X-ray in determining the incidence of gizzard lead among wild flying ducks occurred to us. The supposition was that many ducks remained in Michigan over winter because they were suffering from lead poisoning and consequently in too weak a condition to make the flight south. The relatively much higher cost and greater trouble in obtaining X-ray plates of individual ducks induced us to try the fluoroscopic attachment of a portable X-ray machine as a substitute. It was found soon that the incidence of gizzard lead in wild trapped ducks wintering in Michigan was very low (about 1%) and, in addition, it was somewhat difficult to detect, lying as it often did among partially radio-opaque material in the gizzard and, therefore, necessitating rather long and increasingly dangerous exposure to the X-rays in the course of a

fluoroscopic examination. Use of 35mm. or 70 mm film such as employed in radiographic surveys for tuberculosis in large groups of people is a possibility and may be tried in the future, although there are several serious technical difficulties involved. However, we feel the fluoroscope was sufficiently accurate to establish the generalization that a very small percentage of flying wild ducks in Michigan were carrying gizzard lead.

As so often is the case, a side line to the contemplated main line of research offered more interesting possibilities. Fluoroscopic examination of the first group of trapped ducks (Otter Creek, Monroe County) in midwinter of 1941 gave rather surprising results. Approximately 30 per cent exhibited evidence of having suffered gunshot wounds as shown by the presence of lead shot scattered through their bodies in areas which practically precluded the possibility that we were seeing ingested lead. Seventy of this group were Purple Heart veterans of the duck wars. Difference in shot sizes in some individuals indicated they had been wounded more than once. Eight of the group had healed wing fractures—winged ducks that had risen to fly again.

This group of ducks was trapped in midwinter around large open sulphur springs which never freeze completely even in the severest winter weather. The figures seemed to indicate that these ducks represented a flock of shell-shocked and wounded survivors that could not make the long trek southward. It was somewhat surprising to find approximately the same incidence of wounded but recovered ducks in a group of 131 early Spring migrants (blacks and mallards) trapped at Sugar Island in the Detroit River in the spring of 1941. Almost identically the same result was obtained from a smaller group (51) of late spring migrants trapped at Fish Point in Saginaw Bay.

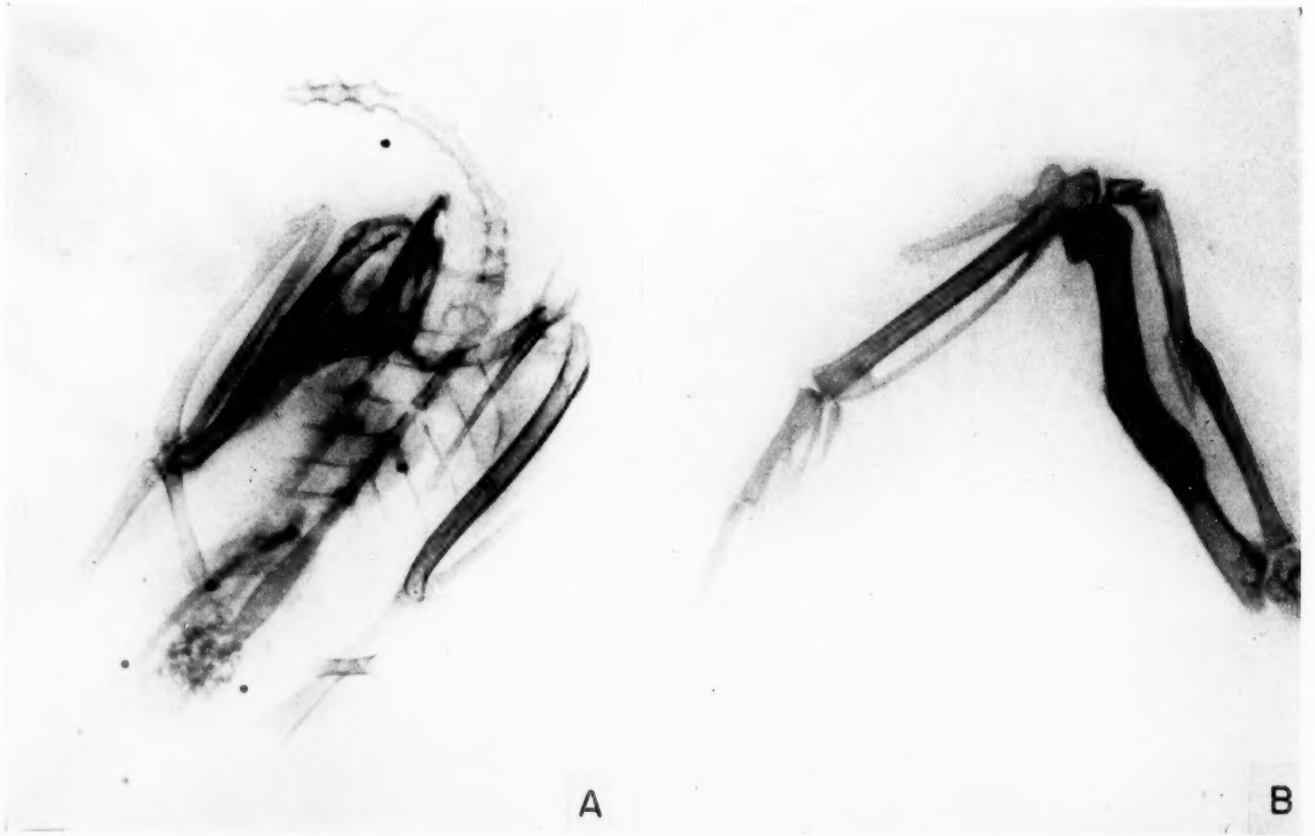
In the winter of 1942 the experiment was repeated in the Detroit River on a group of 436 wintering ducks. The incidence of wounded ducks was in this instance about 23 per cent.

Examination of 105 lesser scaup trapped at the Swan Creek Wildlife Experiment Station in southwestern Michigan gave somewhat different results. About 10 per cent of these ducks were carrying shot in their bodies. We are uncertain as to the explanation although it was interpreted as a specific difference due possibly to fewer contacts with hunters or less resistance to gunshot wounds. Bellrose (1944) in studying the relative vulnerability of the lesser scaup to gun pressure through the years 1939–42 noted a progressive decrease through those years. In 1939 the lesser scaup was about four times more vulnerable than blacks and mallards, but by 1942 due apparently to differences in length of season blacks and mallards had exceeded the lesser scaup in vulnerability. If our results in 1941–42 mean anything the blacks and mallards were certainly bearing the brunt of considerably more gun pressure at that time than the lesser scaup and check reasonably well with the observations of Bellrose in Illinois.

Among the total of over 900 wild trapped ducks, there were 19 individuals (about 2 per cent) that at one time had sustained wing fractures and had recovered to fly again. Most hunters are of the opinion that a winged bird is a dead bird, but these findings indicate that at least a small percentage do recover, although it is small in comparison with the total of those that recover after less serious injuries. In a group of 60 dead ducks picked up in the marshes during the winter, 27 had detectable gunshot wounds. Of these, 13 had sustained wing fractures which apparently had been the mortal factor.

These findings indicate that about one out of every four mallards or black ducks that stay in Michigan over the winter or pass through the State northward in the spring has experienced a gunshot wound. Actually, the figure is slightly larger than this, since ducks are occasionally wounded by perforating shot which leave no trace. Examination of 329 ducks bagged by hunters showed no fluoroscopic evidence of lead shot in about 10 per cent and were evidently killed by one or more shot which passed cleanly through the body. In this group neck and head wounds were apparently largely responsible.

Agencies charged with the responsibility of managing wildlife resources must have reasonably accurate knowledge of populations. They must also know as much as possible concerning the effect of various mortal-



A. X-ray photo showing normal wild (flying) duck containing 10 shot (two sizes) in body. *B*. X-ray photo showing healed wing fracture in normal wild (flying) duck.

ity factors operating to change population levels. Most available evidence tends to show that gun pressure is a very important factor influencing waterfowl abundance, although possibly not the most important. There are decided differences of opinion among groups and persons interested in managing our waterfowl resources as to the importance of gun pressure in affecting population levels.

Pirnie (1935) believes gun pressure to be a very important factor in limiting waterfowl population and cites data from his own banding records at the W. K. Kellogg Bird Sanctuary to support his view.

Phillips and Lincoln (1930) in a general survey of the situation noted the change in gun pressure over the years due to the increasing population and the opening of more public shooting grounds a process which has been greatly accentuated since publication of their book.

Continent-wide censusing and banding studies have given invaluable information concerning the effect of gun pressure on waterfowl. We suggest that our limited and admittedly incomplete study on gunshot wounds in ducks by means of the fluoroscope offers the possibility of still another method of estimating gun pressure on waterfowl if carried out in a systematic manner on a sufficiently large number of ducks. Certainly the presence of lead shot within the body tissues of a duck is indelible and unchanging evidence of that individual's experience with gunfire and we believe that a record of the sum of a good many such experiences in various places and at different times would give us another but not necessarily different concept of the unknown in the equation $man + gun \times ducks = X$.—S. C. WHITLOCK AND H. J. MILLER, *Game Division, Michigan Department of Conservation, Lansing, Michigan.*

LITERATURE CITED

BELLROSE, F. C., JR. 1944. Duck populations and kill. Bull. Ill. Nat. Hist. Surv. **23**: 327–372.

PHILLIPS, JOHN C. and FREDERICK C. LINCOLN. 1930. American waterfowl, their present situation and outlook for their future. Houghton Mifflin Company, Cambridge, Massachusetts, 312 pp., illus.

PIRNIE, NILES D. 1935. Michigan Waterfowl Management. Department of Conservation, Lansing, Michigan. 328 pp., illus.

FOOD HABITS OF THREE COMMON OREGON BIRDS IN RELATION TO REFORESTATION

One of the principal causes for failure of reforestation by direct seeding (i.e., planting seeds instead of nursery-grown trees) is the fact that animals eat the seeds before they germinate. Small mammals are known to cause extensive damage by eating the seeds, but it is not known to what extent birds eat them (Moore, A. W., U.S.D.A., Tech. Bull. No. 706, 1940).

In the period from February 15 to June 15, 1946, the writer analyzed small mammal populations in relation to reforestation in northeastern Tillamook County, Oregon. Small birds were frequently caught in snap traps set for the mammals. Their stomach contents were examined for the purpose of determining whether the birds were eating Douglas fir seeds.

The fir seed together with an equal amount of oats was scattered about the traps to attract animals and was readily available to the birds. The traps were baited with a mixture of raisins, walnut meats and rolled oats, and occasionally with oats. The birds were usually caught when they accidentally stepped into the traps. Occasionally individuals pecked at oats on the trigger.

The species most frequently caught was the Oregon junco, (*Junco oreganus*). White-crowned sparrows, (*Zonotrichia leucophrys*) and spotted towhees (*Pipilo maculata*) followed in order of abundance. The birds were caught at irregular intervals from March 19 to June 3, on land that was logged off 20 to 30 years ago. Part of the area was burned in 1933 and part in 1945.

The relative extent of utilization of oats and Douglas fir seed is shown in Table 1.

TABLE 1.—OATS AND DOUGLAS FIR SEED IN BIRDS' STOMACHS.

	No. of individuals				Stomachs Containing oats	Total no. of oats	Stomachs Containing Doug. fir seeds	Total no. of Doug. fir seeds
	♂	♀	Unknown	Total				
Junco	15	22	2	39	23	70	6	19
White-crowned sparrow	0	5	4	9	8	25	0	0
Spotted towhee	1	1	0	2	1	3	0	0
Totals	16	28	6	50	32	98	6	19

There is an obvious preference shown for oats. Thirty-two of the 50 stomachs examined contained oats, while only six contained Douglas fir seed.

Further evidence that Douglas fir seed is not a preferred item of diet was provided by feeding tray experiments. Several kinds of food, including Douglas fir seed, oats, rolled oats, raisins, suet and griddle cakes, were placed on a tray visited by juncos, Oregon jays, Steller's jays, varied thrushes, white-crowned sparrows, red-breasted nuthatches and a golden-crowned sparrow. Of these, only varied thrushes and juncos are known to have eaten fir seeds. Though juncos ate frequently at the tray, only once was one observed eating Douglas fir seed. Usually they ate oats in preference to all other food. The varied thrushes on the other hand, ate the fir seed in preference to everything else on the tray. However, varied thrushes are not likely to occur on the treeless areas that are being reseeded, so there is little likelihood that they would constitute a significant factor in seed losses.

The foregoing experiment and observations apparently show that during the period studied Douglas fir seed was not a preferred item of food of birds occurring on lands being reforested. If this condition prevails generally it is doubtful that the birds' feeding activities adversely affect efforts to reforest by direct seeding with Douglas fir.

Further evidence is needed on the utilization of fir seed by birds under actual conditions of reforestation practice and during the period of natural reseeding which happens normally from late September to early November. It is hoped that an adequate sample of wild birds can be collected from areas where fir seed has been sown both artificially and naturally. They should be taken by shooting or some other method which does not require the use of bait.—LOWELL ADAMS, *U. S. Fish and Wildlife Service, Missoula, Montana.*

BEHAVIOR AND POST-NATAL DEVELOPMENT OF A PORCUPINE

On May 20, 1944, while riding on the Experiment Station Allotment in Gallatin County, Montana, at an elevation of about 6500 feet, a female porcupine (*Erethizon epixanthum*) was shot as she was climbing a douglas fir. This animal was dissected directly after it was shot and a single foetus was found in the uterus. When released and placed on the ground in the bright sun it showed signs of life within a minute or two and feebly attempted to crawl. The eyes were open and it was fully haired. The quills were wet and limp but soon dried and became stiff and sharp. Its weight shortly after birth was 21 ounces.

Without much hope that it would survive, the porcupine was placed in a paper bag and then in an army-type saddle bag. The horses were either trotted or galloped for nine miles and the conditions inside the saddle bag as it flopped up and down would have been a severe trial to any animal. Yet, upon dumping out the contents of the bag, the porcupine, now quite vigorous, set out at a good pace across the barnyard. Taken back to Bozeman, it was caged and maintained

throughout its life by Mr. David Hurst. Periodical weights are given in the accompanying table. For the first eight days it was fed on sweetened milk with an eye dropper, after that on moist bread and eventually on rabbit pellets. Occasionally various types of greens were given it.

TABLE 1.—WEIGHTS IN OUNCES OF A PORCUPINE RAISED IN CAPTIVITY.

Date	Weight	Date	Weight
May 20, 1944	21 ounces	July 24, 1944	43 ounces
22	21	27	53
24	21	August 8	62
June 1	24	15	110
13	27	December 29	185
16	30	May 12, 1945	192
27	34	January 28, 1946	224
July 5	41	August 18, 1946	250

One behavior trait was deeply ingrained. During the first six or seven months of its life the young porcupine would follow closely anything moving away from him. This trait was apparently not caused by curiosity but was instinctive. In the wild this would keep the young close to their mothers. As a young animal, the porcupine was very friendly and would play with a visitor's feet, rolling and tumbling about. It would even permit Mr. Hurst to pick it up by the tail without sign of fear or anger. At the end of the first year its nature changed and it was as irritable and pig-headed as any adult porcupine, expressing its resentment with both tail and teeth.

At this age the testes could be palpated readily through the abdominal wall. When killed at the age of two years and three months, the left testis was lying just below the skin laterad to the penis and the right testis was in the inguinal canal, each measuring 35×13 mm. No spermatozoa were present in the ductus deferens.

A graph of its growth rate showed two distinct phases. A rapid growth period existed from birth to seven months of age, after which it grew at a much slower rate. If this change in the growth rate coincided with the onset of puberty it would appear that the male porcupine of this species can perhaps mate in December of its first year, a possibility already suggested by other workers. The exact breeding period at this altitude and latitude is not known, but it may well be at this time. The skin and skull of this porcupine are in the Montana State College Museum of Zoology. CLARENCE ARCHER TRYON, JR., *Department of Zoology and Entomology Montana State College, Bozeman, Montana*

WOODLAND CARIBOU IN MINNESOTA

On March 10, 1946 the writer and pilot, Dick Goodrich of the Bemidji Air Lines flew over the big bog north of Upper Red Lake in Minnesota in hope of sighting the Woodland Caribou. We took off at 9.50 A.M. from Bemidji, Minnesota and returned at 1.15 P.M. Almost three hours were spent in flight over the area near Hilman Lake, the last known Caribou range. It was a cold but clear day with perfect visibility. Many deer, twelve moose, and a pair of timber wolves were noted. No caribou or caribou tracks were seen. Flying at two to five hundred feet, tracks in the snow were easily distinguished and identified. Moose and deer trails in the deep snow, which did not appear typical, were followed and double checked; in most instances the deer or moose were nearby, indicating their limited cruising distances during the periods of cold weather and heavy snow. With the exception of an occasional timber wolf track, the open treeless portions

of the bog appeared trackless. We flew over one isolated island of spruce about five acres in size and surrounded by several miles of open bog. A patch of suppressed tamarack on the north edge of the island was being used as a deer yard. Trails were well beaten between beds and at least eleven deer were seen. No deer tracks left or approached the island.

The plight of the woodland caribou in Minnesota and the attempt to restock them has been previously reported. Since 1942 authentic reports on the status of the caribou have been lacking. A number of these, including the observation of tracks of a young caribou late in the winter of 1946, have come to us but they are probably not reliable. Moose, elk, and deer are common in the area and can be mistaken for caribou by the average observer. An aerial survey was made by the Minnesota Department of Conservation in the area during March 1946 but no evidence of caribou was discovered. It should not be assumed from these reports that caribou have disappeared entirely since their potential range covers a vast area and a complete survey would require several days of extensive flying.—URBAN C. NELSON, *Fergus Falls, Minnesota.*

REVIEWS

Forest Soils and Forest Growth. By S. A. WILDE. Chronica Botanica Co., Waltham, Mass., G. E. Stechert and Co., New York City, xvii+225 pp., illus. 1946. $5.00.

Forest Soils and Forest Growth is recommended not only for those who are interested in making successful wildlife plantings and are concerned with site selection, use of fertilizers and nursery practice, but also for those who are interested in the fundamental relationships between soil and ecology. Particular attention has been paid to the botanical composition and productivity of the native vegetation on different soils, so that, although it was written primarily for foresters and soil scientists, it is a comprehensive reference work for biologists. Dr. Wilde quotes Herbert as giving a frank and vivid account of the situation that existed in the not distant past: "Foresters are slowly coming to realize that a knowledge of soils is absolutely essential to all silviculture and management. How well I remember the many hours of careful measurements we used to make to determine the growth and volume of a stand and then kick our heel into the ground, grab a fist full of soil and litter and determine the soil that made this growth possible in the twinkle of an eye!" It is to be hoped that wildlife managers will not neglect the importance of soil in the same way.

Dr. Wilde does not discuss the relationship between animals and the soils which produce them. He limits himself to plants; but his detailed descriptions of forest growth and ground cover often make it possible for the trained ecologist to bridge the gap and translate these into terms of food, cover nesting sites, etc.

References to the extensive bibliography are made in the text making it easy to look up source material for any point in which one is particularly interested. In its basic principles *Forest Soils and Forest Growth* is world wide in scope, making possible comparisons with conditions in other countries.—FRANCES HAMERSTROM.

The California Ground Squirrel: A record of observations made on the Hastings Natural History Reservation. Jean M. Linsdale. Berkeley and Los Angeles, Calif., University of California Press, xi+475 pp., 140 figs., 46 tables, 1946. $5.00.

A moving picture, in words, of the complete daily and annual activities of a diurnal rodent is presented in Dr. Linsdale's account of the bionomics of the California ground squirrel (*Citellus beecheyi*). The facts obtained, from years of observations by more than a score of workers, are more complete than for perhaps any other wild rodent. The details are as thoroughly investigated as if the study had been made in the indoor laboratory, yet the significance of the information gained is greatly enhanced by the fact that the observations are based on happenings in nature. Some animals have been dissected to supplement the field observations. The study includes "the whole range of squirrel behavior" at the Hastings Reservation, in the grassland area of the Santa Lucia Mountains, in Monterey County, California. Study and description of the variation of behavior is included, for the "extremes may have more importance than the average in the welfare of the species." Although the book is not intended as a management study or a report on how to control ground squirrels, there is included in it much valuable information on these subjects.

Man's economic interests in cultivating and grazing more land, introducing new plants, and removing the mat of vegetation has, in Linsdale's opinion, been essential in increasing the number of California ground squirrels. In some cases, "the presence of squirrels in large numbers may be a symptom of unsuitable use of the land and they may become reduced after the misuse is corrected. The more nearly natural the cover of vegetation the less likely it is that squirrels can be unduly numerous and therefore injurious." Ways of controlling concentrations of squirrels can be accomplished, in addition to killing them, by destroying their burrows or permanently blocking the entrances, and on pasture land, by fencing out the domestic stock from the sites most suitable for colonies.

In the chapter on "Habitat," Linsdale points out that the burrow system of the colony is a structure of permanence, extending over several generations. In spite of the colonial nature of such a system, one squirrel may show preference for a burrow "so that a more or less accurate estimate of numbers may be made on the basis of users per burrow opening." Alterations in activity of the ground squirrel parallels changes of relative humidity, but Linsdale cautiously points out this may not be a direct influence. Sunshine must influence the activity of the squirrel also, for the squirrels expose themselves to it at every opportunity and the warmth obtained "may serve to heat the skin, thus causing ectoparasites to leave the animal." Complicated methods of communication among these animals are important in developing the colonial habit. The chapter on "Activity" includes a discussion of dormancy. Many squirrels neither estivate nor hibernate at this locality, but of those that do both, those that estivate possibly do so without storing food but by building up a deposit of fat, and come out of dormancy in the fall to store food preliminary to hibernation. Under the heading of "Associated Vertebrate Animals," it is pointed out that dorsal skin glands may be of use to discourage capture by carnivores. Food is primarily of plant material, five of some 60 kinds being preferred. The chapter on "Diseases and Parasites" includes a good review of plague and plague work in California, as well as an account of the known external and internal parasites recovered from squirrels on the Hastings Reservation. In the account of "Reproduction," Linsdale points out that the breeding season is restricted to a small segment of the year and as a result a chance for replacement of lost young is removed. Compensating for this hazard is an increase in size of litter. So many factors influence the numbers of squirrels to be counted, such as "below ground" and dormant, variation in environment, and shifting of populations seasonally, that no generalizations as to numbers can be made nor is it advisable, apparently in the author's estimation, to give the numbers per acre. A chapter on "Structure" describing the external anatomy and some of the gross internal anatomy will have special appeal to the public health investigator.

In spite of the intensiveness of this investigation many problems concerning the biology of the California ground squirrel remain only partially or conjecturally answered. This report should stimulate other workers to more minutely investigate some of these problems and should set a standard for others planning to study wild mammals. The reader of Linsdale's account will encounter much repetition of observations and of minute detail, but the author feels "it may be necessary to cite the same element in many examples." Some of the repeated observations might have been put in smaller type as well as some of the material in the chapter on reproduction. Much of the information on structure of these animals is based on a single specimen with no indication of the kind or amount of variation. "Literature cited," containing only 51 titles, most of which do not pertain directly to the California ground squirrel, would not be expected to be large, for this book is based primarily on original observations.

Linsdale's *The California Ground Squirrel* is a book that every wildlife technician, ecologist, public health worker, and mammalogist must consider. It offers a challenge and a lead for similar investigations with other mammals. —DONALD F. HOFFMEISTER.

Mammals of California. Lloyd Glenn Ingles. Stanford University, Calif., Stanford University Press. xix+258 pp., 42 pls., 57 figs. Feb. 20, 1947. $4.00.

There has long been a need for an up-to-date, complete, single account of the mammals of the state of California, for previously only parts of the mammalian fauna of California have been intensively studied and written about. Bryant's 1891 and Stephen's 1906 reports are long out of date, and Grinnell's "Mammal Fauna of California" of fifteen years ago was intended only "as a progress report." Lloyd Ingles' *Mammals of California* will fill at least part of this need, for he offers "in popular form," "for the beginner," a text that should assist the elementary student. The excellent photographs of many of the species of the mammals of California, and numerous line drawings of

their tracks, add immeasurably to the value of the book. Numerous keys and range maps are designed to help identify any species. For some species of nearly every genus, life history information is included, although synonymies, type localities, precise ranges, and lists of specimens examined are not.

In the *Mammals of California*, there is no special attempt made to present new information about the mammals of the state, but rather a resynthesis and compilation of a small part of the data and information already available. Some of this information the author has recorded in an incomplete or inaccurate fashion. For example, some species, such as *Sorex willetti* von Bloeker and *Myotis ruddi* Silliman and von Bloeker, are omitted entirely and there are no accounts of some other species, such as the black rat (*Rattus rattus*) and the tule elk (*Cervus nannodes*). The scientific terminology is not up-to-date for the deer (*Odocoileus hemionus* instead of *O. columbianus*) and for the snowshoe rabbit (*Lepus americanus* for *L. washingtonii*). No attempt is made to evaluate the current nomenclature and as a consequence four full species of jumping mice are listed as occurring in California. Range maps, of so much value to the student, are not included for the bats and carnivores. Available publications would have given the necessary information to prepare "general" range maps for these species. Some other range maps do not include more recently published extensions of range. Statements such as the "large glands [of the beaver] . . . open through the *cloaca*," "a mole . . . *fits* a niche," or "the tail [of the grasshopper mouse] is *frequently* thick and tapering," italics mine, may confuse rather than assist the aspiring neophyte. In a dichotomous key to the four species of wood rats occurring in California, the desert wood rat and the dusky-footed wood rat each appear three times!

The wildlife worker will be pleased with the sound remarks the author presents, in the introduction, on conservation, balance of nature, and control of wild mammals, all intended for the beginner. One cannot help but sympathize with Ingles in his dilemma to find acceptable common names to assign to each species of mammal. Mammalogists could profitably draw up, at least for the United States, a standard list of appropriate vernacular names for full species, avoiding vernacular names for geographic variants (subspecies). —DONALD F. HOFFMEISTER.

OBITUARY

WALTER CLEAVELAND HENDERSON
1876–1947

Walter Cleaveland Henderson, who joined The Wildlife Society during its first year and was elected to the Active class in 1938, remained in our ranks for the rest of his life. He died of coronary thrombosis in St. Petersburg, Florida, January 1, 1947, and was buried there.

Mr. Henderson was born in Chelsea, Massachusetts, on July 6, 1876, and was educated in the Chelsea and Somerville public schools and in Boston University Law School from which he was graduated (LLB) in 1903. He had already entered the Federal Service and was employed in the Customs Service of the Treasury Department from 1897 until 1907, when he was appointed law clerk in the Forest Service, Department of Agriculture. Later he became assistant to the Solicitor of that Department and on December 1, 1916, was transferred to the Bureau of Biological Survey as Assistant Chief. In 1927 he was made Associate Chief and upon the consolidation in 1940 of the Biological Survey with the Bureau of Fisheries to form the present Fish and Wildlife Service, he was made Assistant Director. Suffering some impairment of health, evidenced principally by sciatica, he did not move to Chicago with the bulk of the Bureau in 1942, but retired on November 30 of that year. His span of Government service was 45 years.

Mr. Henderson was Chairman of the War Memorial Committee of the U. S. Department of Agriculture, through whose inter-

mediacy a beautiful and dignified monument to employes of the Department who gave their lives in World War I was placed in the patio of the Department's Administrative Building. The Committee also published in excellent form a volume containing photographs and biographical sketches (by Frederick C. Lucas) of the fallen men.

He was a member of several scientific societies, among them the American Association for the Advancement of Science, American Ornithologists' Union, American Forestry Association, National Conservation Association, National Association of Audubon Societies, Cooper Ornithological Club, American Society of Mammalogists, Baird Ornithological Club, the National Geographic Society, and the Biological Society of Washington, D. C. He also belonged to the bar of the U. S. Supreme Court and the fraternity Epsilon Pi.

Because of his legal and administrative experience, Mr. Henderson was brought to the Biological Survey by E. W. Nelson, Chief, to improve its administration, and he did so. It was his practice to study all sides of any matter coming before him; if there was no one to represent the opposition, assuming the attorney's role, he would do it himself. He was unemotional and judicial and made a reputation among the employes for thoroughgoing fairness. His success in this field was so great that he was asked to handle the most difficult personnel problems of the organization and even when censure or discipline was necessitated, he won the esteem and even the friendship of the victim. That there was great respect and liking for him throughout the organization was manifested by the flood of letters of appreciation that came in for a memorial volume that was presented to him after his retirement.

He was always a student and in evening courses at George Washington University, won the A.B. degree in 1926. The better to fit himself for his work in the Survey, he later continued in the same manner postgraduate studies with emphasis upon biology. His constant desire to improve his mind (and it was an extraordinarily good one) was in evidence throughout the years; near the close of his official career, both in school and out, he was striving for proficiency in the Spanish language—a study doubtless started in the interest of better handling of the Convention between the United States and Mexico for the protection of migratory birds and game mammals that was ratified in 1937.

Mr. Henderson was a conservationist, and with a few other members of the Biological Survey, carried on a fight in the early thirties to save the waterfowl, then at a dangerously low ebb. His speech before the New England Wildlife Federation at Boston in January 1930 was the first public statement by the Survey that too many waterfowl had been taken by hunters and that the annual kill must be curtailed if the birds were to be preserved. Restrictions were put into effect but at a great cost in hunter criticism and opposition. However, Mr. Henderson survived the attacks and after a brief period of ascendancy on the part of the gunners and their representatives, he was advanced in position and authority. In his relations to the Bureau and to Federal policy, he was meticulously loyal even at times, I am sure, when his personal convictions were not in agreement.

Briefly as to his private life, Mr. Henderson in 1908 married Margaret L. Orpin, who with their son Fletcher survive him. When it became evident that the United States would be involved in World War I, he joined one of the rifle clubs, popular at that time, and assisted in the unofficial instruction of younger men in the use of the government rifle and pistol. For some time he continued target shooting as a sport, then changed over to golf, in which he became more than ordinarily proficient. In retirement at St. Petersburg, he participated in bridge and chess playing, and in shuffle-board, with his son, soon won and held the father and son championship of the city. There, still inbued with the spirit of learning, he continued his purposeful reading. Gaining knowledge and applying it were characteristic of his career. He was a grand character and a great friend.
—W. L. McATEE.